MANUAL

GEIRS Installation and User's Manual

Document: CARMENES-AIV04B-NIR-DCS-MAN01

	Name	**Centre**	**Date**	**Signature**
Prepared:	R. J. Mathar	MPIA	December 10, 2015	
Revised:				
Approved:				
Authorised:				

Document change record

Issue	**Date**	**Section / paragraph / page**	**Change description**
0.266	23 Sep 2013	All	first version
2.344	December 10, 2015	All	current version

Contents

1 OVERVIEW

1.1 Design

The Generic Infrared Software (GEIRS) is a software layer written almost entirely in ANSI-C, which

- assembles parameter lists and commands received from its own graphical interface or other supervisor software,
- translates these into the firmware language ("patterns") of the readout electronics (ROE)
- initializes the readout cycles
- and accumulates the frames received from the ADC's of the electronics as FITS files or X11 images.

The *generic* attribute of the name illustrates that the core part of the software has been adapted to generations of the MPIA electronics which controlled various infrared detector chips in the past 20 years. In consequence, the command library is a superset of functionality released for a set of cameras in the past, and in the future.

The software comprises pieces of instrument and telescope control software written for other observatories, as will become obvious and will be discussed at the subsection affected. Graphical user interfaces slavishly reflect—following established paradigms of good software practise—underlying batch processing capabilities, so some of the buttons or menus are either dead-ended, wiped out or set to invariable constants.

This document summarizes

- the system setup (installation, compilation);
- the graphical user interface for the standalone setup, that is, the system running without supervision or interference by any camera control software [1]. This might be the least important part during production (after commissioning);
- the command interface;

A recent version of this document is in this PDF, the subversion system of the source code, and the `GEIRS`/*version*/`doc` subdirectory of the source code on the computers where GEIRS is installed.

The software is currently developped under openSUSE 13.2 with gcc version 4.8.3, Java JDK 1.8.0_-40, perl 5 (version 20) and PLX SDK 7.20.

1.2 Interfaces

The document complements the documents on the camera control software [1], the FITS format [2], ROE [3], readout patterns [4], installation and pattern generator [5, 6].

1.3 Operation

GEIRS is installed by adding drivers of the PLX board at standard places to the Operating System, configuring the allowable shared memory parameters, retrieving the source code and the pattern descriptions from a SVN repository, and compiling the source code with the GNU C/C++ compiler.

GEIRS is started with a one-line command to the Operating System with an option to start with or without interactive GUI support. The configuration of essentially permanent parameters (TCP interfaces to the ROE, the location of files concerning patterns, sound control, etc.) is done in the very same startup-script. This needs of the order of five seconds. There is no "initialization sequence" because essentially all parameters concerning exposures are forwarded later.

Health of the GEIRS command interface and shared memory manager may then and at any latter time be checked by querying parameters with the `status` command. More tests by scanning the log files for prototypical answers from the ROE are possible if initialization tests are needed.

The standard operation of generating the images (that is, generating the FITS files) is to send a sequence of commands to the GEIRS "shell." There are configurational commands that specify ROE parameters like integration times, integration/readout types, repetition factors, location and size of windows in the geometry, and names of the FITS files. After such preparational step, the two commands `read` (start ADC conversion and data transfer between ROE and the host computer), and `save` (convert RAM-data to FITS file(s)) define the fundamental cycle of generating the images. The configuration may be changed after each read-save cycle. This allows the higher level control software to examine (the quality of) the FITS images before starting another exposure with the same or modified parameters.

To simplify operations, any sub-sequence of these commands may be packed into macros (ASCII files in a subdirectory) which are callable by a single command.

GEIRS is shut down by sending a `quit` command to the command interpreter.[1] This leaves the ROE in its most recently selected idle-mode (until powered off). Instruments specific aspects will probably be bundled in a set of macro files related to scenarios like calibration/flat- fielding and/or star magnitudes once the details of the windowing and timing patterns are fixed.

1.4 Acronyms

2MASS	`http://www.ipac.caltech.edu/2mass/releases/allsky/index.html`
ADC	analog-to-digit conversion
ADU	analog-to-digital unit
ANSI	American National Standards Institute `http://www.ansi.org`
ASCII	American Standard Code for Information Interchange `http://http://en.wikipedia.org/wiki/American_Standard_Code_for_Information_Interchange`
CAHA	Calar Alto Astronomical Observatory `http://www.caha.es`
CARMENES	Calar Alto High-Resolution Search for M Dwarfs with Exoearths with Near-infrared and Optical Echelle Spectrographs `carmenes.caha.es`

[1]The various ways are to click the `shutdown` button in the `controls` GUI, to type in `quit` in the GEIRS shell, or to use `quit` as the argument to the `geirsCmd` or to the `cmd_*` Linux executables.

ccw	counter clock wise
CPU	Central Processing Unit
cw	clock wise
DAC	digit-to-analog converter
DEC	declination coordinate of the ICRF
DMA	Direct Memory Access
DNS	Domain Name Service
EPICS	`www.aps.anl.gov/epics`
FIFO	first in first out `http://en.wikipedia.org/wiki/FIFO`
FITS	Flexible Image Transport System `http://fits.gsfc.nasa.gov`
FPGA	Field programmable gate array
FWHM	Full width at Half Maximum
GEIRS	Generic Infrared Software
GNU	`www.gnu.org`
GUI	Graphical User Interface
HDU	header-data unit (of FITS)
HTML	Hypertext Markup Language `http://en.wikipedia.org/wiki/HTML`
IP	Internet Protocol
ISO	International Organization for Standardization `http://en.wikipedia.org/wiki/ISO`
LBT	Large Binocular Telescope `http://www.lbto.org/`
LED	Light Emitting Diode
LINC-NIRVANA	LBT Interferometric Camera and Near-Infrared / Visible Adaptive Interferometer for Astronomy
LN	liquid nitrogen
LN	LINC-NIRVANA
LUCI	LBT NIR spectroscopic Utility with Camera and Integral-Field Unit for Extragalactic Research `http://www.mpe.mpg.de/ir/lucifer`
MEF	Multi-extension FITS
MIDAS	Munich Image Data Analysis System `http://www.eso.org/sci/software/esomidas/` `ftp://ftp.eso.org/pub/midaspub/`
MPIA	Max-Planck Institut für Astronomie, Heidelberg `http://www.mpia.de`

NIR	near infrared
NIRVANA	Near-Infrared / Visible Adaptive Interferometer for Astronomy
NTP	Network Time Protocol http://en.wikipedia.org/wiki/Network_Time_Protocol
OPD	optical path difference
OT	Online Tool https://panic.iaa.es
PANIC	Panoramic Near-Infrared Camera https://panic.iaa.es
PCI	Peripheral Component Interconnect
PCIe	Peripheral Component Interconnect Express http://en.wikipedia.org/wiki/PCI_Express
PCI-X	Peripheral Component Interconnect eXtended http://en.wikipedia.org/wiki/PCI-X
PDF	Portable Document Format http://en.wikipedia.org/wiki/Portable_Document_Format
PLX	PLX Technology, Sunnyvale, CA http://www.plxtech.com
RA	Right Ascension
RAM	Random Access Memory
RoCon	Readout Controller
ROE	Readout Electronics
RPM	RPM Package Manager http://docs.fedoraproject.org/en-US/Fedora_Draft_Documentation/0.1/html/RPM_Guide/index.html
ST	Sidereal Time
SVN	Subversion http://subversion.apache.org
TCP	Transmission Control Protocol http://en.wikipedia.org/wiki/Transmission_Control_Protocol
URI	Universal Resource Identifier http://en.wikipedia.org/wiki/Uniform_resource_identifier
UT	Universal Time
UTC	Universal Time Coordinated
WCS	World Coordinate System http://atnf.csiro.au/people/mcalabre/WCS/

1.5 References

References

[1] C. Storz, LINC-NIRVANA - Infrared Camera Control Software, lN-MPIA-FDR-ICS-005 (6 Jun. 2005).

[2] M. L. del Fresno, J. A. Caballero, CARMENES - Final design - Data-Image headers, FDR-11A (01 Feb. 2013).

[3] U. Mall, C. Storz, CARMENES - NIR channel – Readout electronics and software, FDR-04C2A. E: in section 2.6.2 the factor 0.5 of the voltage divider is wrong. The actual value for the CARMENES racks is 0.699. (30 Jan. 2013).

[4] V. Naranjo, LINC-NIRVANA - IR Detector Control Pattern, LN-MPIA-DES-ELEC-007 (5 Apr. 2008).

[5] R. J. Mathar, LINC-NIRVANA - Generic Infrared Software, Pattern Constructor, LN-MPIA-MAN-ICS-008 (13 Feb. 2013).
URL `http://www.mpia.de/~mathar/public/LN-MPIA-MAN-ICS-008.pdf`

[6] C. Storz, V. Naranjo, U. Mall, J. R. Ramos, P. Bizenberger, J. Panduro, Standard modes of MPIA's current H2/H2RG-readout systems, in: 2012 Astronomial Telescopes and Instrumentation, Vol. 8453 of Proc. SPIE, Int. Soc. Optical Engineering, 2012, p. 2E. `doi:10.1117/12.927170`.

[7] J. R. Ramos, ROCON REad-out Controller Board (Nov. 2009).
URL `webdavs://sk1/geirs/roe3MPIA/Roconv3-Draft.pdf`

[8] U. Mall, How to change the IP address of the MPIA ReadOut Electronics (19 Feb. 2015).

[9] R. J. Mathar, GEIRS Application Notes, cAHA-MAN-MPIA-GEIRS-0001 (24 Apr. 2015).

[10] I. F. W. Group, Definition of the flexible image transport system (FITS) (2005).
URL `http://fits.gsfc.nasa.gov/iaufwg`

[11] R. L. White, P. Greenfield, A scheme for compressing floating-point images, Vol. 172 of Astronomical Data Analysis and Systems, ASP, 1999, p. 125.

[12] J. Panduro, V. Naranjo, Linc-nirvana - science detector readout mode comparison, Tech. rep., LN-MPIA-TN-ELEC-007 (19 Oct. 2012).
URL `https://svn.mpia.de/trac/gulli/ln/archive/Archive/LNDocumentation/TechnicalNotes(TN)/Electronics,includingdetectors(ELEC)/LN-MPIA-TN-ELEC-007-ScienceDetecorReadModeComparison/LN-MPIA-TN-ELEC-007.pdf`

[13] R. Blank, S. Anglin, J. W. Beletic, S. Bhargava, R. Bradley, C. A. Cabelli, J. Chen, D. Cooper, R. Demers, M. Eads, M. Farris, W. Lavelle, G. Luppino, E. Moore, E. Piquette, R. Ricardo, M. Xu, M. Zandian, Hr2rg focal plane array and camera performance update, in: A. D. Holland, J. W. Beletic (Eds.), High energy, optical and infrared detectors for astronomy V, Vol. 8453 of Proc. SPIE, Int. Soc. Optical Engineering, 2012, p. 84531D. `doi:10.1117/12.926752`.

[14] R. J. Mathar, CARMENES - NIR First Stage Pipeline, CARMENES-AIV-04B-NIR-DCS-MAN02 (04 Nov. 2015).
URL `http://www.mpia-hd.mpg.de/~mathar/public/CARMENES-AIV04B-NIR-DCS-MAN02.pdf`

[15] N. Capitaine, M. Folgueira, J. Souchay, Earth rotation based on the celestial coordinates of the celestial intermediate pole. 1 the dynamical equations, Astron. Astrophys. 445 (1) (2006) 347–360. `doi:10.1051/0004-6361:20053778`.

[16] N. C. P. T. Wallace, High precision methods for locating the celestial intermediate pole and origin, Astron. Astrophys. 450 (2) (2006) 855–872. `doi:10.1051/0004-6361:20054550`.

[17] A. H. Rots, P. S. Bunclark, M. R. Calabretta, S. L. Allen, R. N. Manchester, W. T. Thompson, Representation of time coordinates in FITS. time and relative dimension in space., Astron. Astrophys. 574 (2015) A36. `doi:10.1051/0004-6361/201424653`.

[18] V. Naranjo, J. Panduro, CARMENES Detector Characteriation – NIR channel - Sensor Array Mosaic (27 Mar. 2015).

[19] A. M. Fowler, I. Gatley, Noise reduction strategy for hybrid ir focal-plane arrays, in: T. S. J. Jayadev (Ed.), Infrared Sensors: Detectors, Electronics, and Signal Processing, Vol. 1541 of Proc. SPIE, Int. Soc. Optical Engineering, 1991, pp. 127–133. `doi:10.1117/12.49326`.

[20] A. M. Fowler, I. Gatley, Demonstration of an algorithm for read-noise reduction in infrared arrays, Astrophys. J. 353 (1990) L33–L34. `doi:10.1086/185701`.

[21] C. Cárdenas, E. Sánchez, CARMENES - NIR channel – Final Optical Design, FDR-TRE028 (24 Apr. 2012).

[22] MPIA, MoCon (Motion Controller Board) Programmer's Guide, moconProgrammersGuide (Nov. 2010).

[23] U. Mall, IR ReadOut Electronics Technical Manual, 1st Edition (Jan. 2013).

2 INSTALLATION

2.1 External Software

2.1.1 Plx

The Linux driver for the PCI bus delivered by the manufacturer (PLX) of the main chip on the OPTPCI board (which is designed by MPIA) is expected to be installed in `/usr/src`, which needs root privileges. If these header files and driver libraries are not found at GEIRS compile time, the software will always run in ROE software simulation.

The following instructions are a summary of the documentation found in the directory `Documentation/PLX_Linux_Release_Notes.htm` of the driver. You are strongly advised to recompile the driver each time a kernel update was installed in `/usr/src`—which happens a few times per year under a well-maintained operating system.

Details may differ. In particular, the version will change as time progresses. The symbolic link installed below ensures that the header files are always found in `/usr/src/PlxLinux/PlxSdk/Include` and that `admin/plxload` finds the driver to install. We build only the drivers for the two PLX chips that have been in use by the MPIA electronics: 8311 (newer, PCIe, OPTPCI-e, the relevant one for LUCI1/2, LN, PANIC and CARMENES) and 9656 (older, PCI-X, OPTPCI, still on duty on some MPIA computers). The manufacturer's imprint on the fattest chip onboard the OPTPCI shows immediately which of the two types is in use.

The PLX drivers are currently not under SVN control. This is third party software and distribution of the complete SDK package is explicitly *not* covered by the license.

1. If this follows a fresh installation of the operating system, the kernel drivers in the directory `/usr/src/linux-?.?.?` may be missing. This will lead to complaints of the form

   ```
   make: *** /lib/modules/3.11.6-4-desktop/build: No such file or directory.  Stop.
   make: *** [BuildDriver] Error 2
   ```

   when the PLX driver is installed further down. This is the case if the following test does not find the `build` directory of the Linux distribution of the current system:

   ```
   unamer=‘uname -r‘
   cd /lib/modules/${unamer}/build
   ls -l include
   ```

   This usually means that openSUSE was installed without the "developer" version of the kernel—which is one of the options while installing the OS but not included by default. This is basically cured by running `/sbin/yast2`, selecting the `Software Management`, the `Repositories`, and post-installing the `kernel-deskop-*` packages. On a freshly installed CentOS 7 the error message was triggered by an incorrect symbolic link to a non-existing `build` directory in `/lib/modules/3.10.0-123.6.3.el7.x86_64`, which had to be repaired.

2. We start from the Linux version distributed by PLX, unbundle everyting in `/usr/src` and first set two enviroment variables (which are obviously extracted from the corresponding portions of the file name):

   ```
   cd /usr/src
   export PLX_SDK_VERSION_MAJOR=7
   export PLX_SDK_VERSION_MINOR=20
   plxdir=PlxLinux_v${PLX_SDK_VERSION_MAJOR}.${PLX_SDK_VERSION_MINOR}
   mkdir $plxdir
   # Caution: if you have more than one version, link the one just extracted...
   rm ./PlxLinux ; ln -s $plxdir ./PlxLinux
   mv PLX_SDK_Linux_v*${PLX_SDK_VERSION_MINOR}*.zip  $plxdir
   cd PlxLinux
   unzip *.zip
   tar xf *.tar
   cd PlxSdk
   export PLX_SDK_DIR=‘pwd‘
   make cleanall # if above was done by copying binaries around
   ```

   If this is release 7.00 or earlier, add the lines

   ```
   #if (LINUX_VERSION_CODE >= KERNEL_VERSION(3,7,0))
       #define VM_RESERVED                  (VM_DONTEXPAND | VM_DONTDUMP)
   #endif
   ```

at the beginning of the file `Include/Plx_sysdep.h`. This is strictly only needed for Linux kernel versions from 3.7 on, as revealed with `uname -r`, but it does not harm anyway. With the current CentOS 6.4 based on a Linux 2.6 kernel, compilation will still work with the PLX SDK 6.50, whereas openSUSE distributions 12.x and higher will need PLX SDK 7.00 or higher. Continue with

```
if [ ${PLX_SDK_VERSION_MAJOR} -gt 6 ] ; then
    # for release versions 7.00 and higher
    cd Driver ;
else
    # for release versions up to 6.50 inclusive
    cd Linux/Driver ;
fi

./buildalldrivers
cd ../PlxApi
make clean ; make
```

Ensure that real-time properties are preserved by moving ownership to `root` and that the general user can read these files while compiling GEIRS:

```
find $PLX_SDK_DIR -type d -exec chmod a+rx {} \;
find $PLX_SDK_DIR -type f -exec chmod a+r {} \;
find $PLX_SDK_DIR -exec chown root {} \;
find $PLX_SDK_DIR -exec chgrp root {} \;
```

The directory layout is then similar to

```
lrwxrwxrwx 1 root root 14 Jan 27 2012 PlxLinux -> PlxLinux_v7.11
drwxr-xr-x 4 root root 4096 Jan 27 2012 PlxLinux_v7.11
```

3. To include the driver each time the computer is (re)booted
   - Under openSUSE 13.1 and older, copy `GEIRS/`*branch*`/admin/plxload*` to `/etc/init.d` and enable it with

     ```
     cd /etc/init.d
     chmod +x plxload8311
     chmod +x plxload9656
     /sbin/insserv plxload8311
     /sbin/insserv plxload9656
     ```

   - Under CentOS 7 and openSUSE 13.2 and newer, `plxload*` is copied in the "old-fashioned" way to `/etc/rc.d/init.d/`, then

     ```
     chkconfig --level 345 plxload8311 on
     ```

   - Under CentOS 6.3, `insserv` is not (yet) available, so `plxload*` is copied in the "old-fashioned" way to `/etc/rc.d/init.d/`, and links named `S99plxload` and `K99plxload` back to this file are added in `/etc/rc.d/rc5.d`.

These steps are not needed and actually fail if no PLX device (read: no OPTPCI board) is found on the local bus system. Caveat: if this is automatism is not added, each invocation of GEIRS or any of the tests involving the OPTPCI board (i.e., everything beyond running GEIRS with ROE in simulation) needs to call either the wrapper script

```
plxstartup
```

or

```
/sbin/service plxload8311 restart
```

at least once (which needs `root` privileges).

4. A simple check of successful loading of the driver is that

   ```
   lsmod | fgrep Plx
   ```

   contains the `Plx8311` entry and that

   ```
   /sbin/service --status-all
   ```

   contains a line which mentions `PLX driver loaded`. If you have root permissions,

   ```
   cat /proc/vmallocinfo | fgrep Plx
   ```

   should show three lines for each OPTPCI board plugged into the computer.

Each time the driver is recompiled, *all* GEIRS versions need to be recompiled because they are linked with the binaries in the `/usr/src` directory, Section 2.3.[2]

2.1.2 Autotools

The GEIRS compilation is based on a recent version of GNU autotools, in particular on `autoconf` at least at version 2.68. If your configuration is too old, an update of the autotools ought be installed in the local user's directory who will compile GEIRS as follows. First ensure that `$HOME/bin` is in `$PATH` prior to the paths of the (old) tools. Download `m4` from `ftp://ftp.gnu.org/gnu/m4/` and install with

```
tar -xzf m4-1.4.17.tar.gz
cd m4-1.4.17
./configure --prefix=$HOME
make
make install
m4 --version
```

Then download `libtool` from `ftp://ftp.gnu.org/gnu/libtool/` and install with

```
tar -xzf libtool-2.4.6.tar.gz
cd libtool-*.6
./configure --prefix=$HOME
make
make install
libtool --version
```

[2]The step that dives into the `extern` directory of the GEIRS source code can be skipped to save some time, because none of the external packages links with the PLX driver. The `configure`, `make` and `make install` steps in the top source need to be redone.

Then download `autoconf` from `http://ftp.gnu.org/gnu/autoconf/` and install with

```
tar -xzf autoconf-2.69.tar.gz
cd autoconf-2.69
./configure --prefix=$HOME
make
make install
autoconf --version
```

Then download `automake` from `ftp://ftp.gnu.org/gnu/automake/` and install with

```
tar -xzf automake-1.15.tar.gz
cd automake-1.15
./configure --prefix=$HOME
make
make install
automake --version
```

For each of the packages grab the most recent versions;[3] the versions quoted above are for illustration only.

2.1.3 Compilers

In case the person to install the operating system did not have have software development in mind and just went on with the standard distribution, various developer packages will be missing.

c++ The GNU C++ compiler is not distributed with the default layout of openSUSE 13.1. If

```
which g++
```

revals that this is the case, use `/sbin/yast2`, the `Software management`, search for `gcc` and post-install the packages. Include the Fortran packages, because there is still HEASOFT software that is written in Fortran.

gcj The GNU Java compiler is not distributed with the default layout of openSUSE 13.1. If

```
which gcj
```

revals that this is the case, use `/sbin/yast2`, the `Software management`, search for `gcj` and post-install all `gcj` packages.

Under CentOS, there is no such `gcj` package. This means one would need to compile the (fuller) version of `gcc` for example as described in recompileGCC.pdf.

Note that this particular compiler is not needed to compile GEIRS because it will fall back on the Oracle JDK if that is installed.

[3]The exception are machines where `TwiceAsNice` is to be compiled, which does not work with `automake 1.15` yet.

flex The `flex` ompiler is not distributed with the default layout of openSUSE 13.1. If

```
which flex
```

revals that this is the case, use `/sbin/yast2`, the `Software management`, search for `flex` and post-install it.

readline The `readline` library is not distributed with the default layout of openSUSE 13.1. If the GEIRS installation does not find the header files, it compiles and installs its own copy of the library in its local directory; this is a waste of time. So it is recommended, if `/usr/include/readline/readline.h` is missing, to post-install the package with

- `/sbin/yast2` or `zypper in readline-devel` under openSUSE
- or `yum install readline-devel` under CentOS.

2.1.4 boost

GEIRS uses the `regex` package of the `boost` library. Two major ways of failing to have it have been detected so far. If the library is not found under openSUSE it suffices to run `/sbin/yast2` the `Software management` submenue, to search for `boost` and to install the subpackages.

Under CentOS the library can be obtained with

```
yum install boost boost-devel
```

under root. On old operating systems the following installations on the local user's file system may otherwise be needed:

CentOS or openSUSE with gcc 4.8 Under CentOS 6.3/6.4, the boost library seems to be incomplete and needs to be installed separately before compiling GEIRS. The source is taken from `http://sourceforge.net/projects/boost/` and compiled with

```
tar -xzf boost*.tar.gz
cd boost*_0
./bootstrap.sh --prefix=$HOME
./b2 install
```

CentOS with gcc 4.4 The compilation in the previous paragraph does not work using the old gcc 4.4.7—which is the CentOS 6.4 default unfortunately still relevant to LUCI—and results in tons of compiler errors. Since only the `regex` library will be needed, it suffices to compile this part alone. Usually this requires to build `bjam` first. Two installation options:

- If you do not have root access, start from the source from `http://sourceforge.net/projects/boost/files/boost-jam/` and compile `bjam` with

```
tar -xzf boost-jam*.tgz
cd boost-jam-3*
sh ./build.sh
cd ~/bin
ln -s ~/boost-jam*/bin.*/bjam .
```

- If you do have root access, run

  ```
  yum install boost-jam
  ```

The `regex` is then compiled by running `bootstrap.sh` and `b2` as above followed by

```
cd boost_1_*/libs/regex/build
bjam install
```

2.1.5 Other

gnuplot Gnuplot will be called to create 2D plots with horizontal and vertical cross cuts and 3D plots of the detector images if clicking the `plot` button in the images GUI. If the executable `gnuplot` is not found when GEIRS is compiled, all associated graphing functionality will be disabled. The recommendation is: if

```
which gnuplot
```

does not find the executable, install the package

```
zypper install gnuplot
```

under openSUSE or the equivalent `yum install gnuplot` under CentOS.

within GEIRS Further external packages (cfitsio, CCfits, texinfo, sofa and parallel) in the `GEIRS/`*branch*`/extern` subdirectory are compiled later with the main source code. If the compilation of `cfitsio` does not suceed because no acceptable Fortran compiler is found, this may mean that `/usr/bin/gfortran` is missing. Use

```
zypper search fortran
zypper install gcc-fortran gcc48-fortran
```

to install the packages, or the equivalent `yum` on CentOS.

2.2 Obtaining the Source Code and Patterns

- With subversion (SVN), the current (read: potentially unreliable) source is extracted with a script like

```
export CAMHOME=${HOME}/GEIRS
mkdir -p $CAMHOME
cd $CAMHOME
mkdir -p INFO MACROS CATS OBJECTS

# export a branch or the trunk of svn
# cd $CAMHOME ; svn checkout https://svn.mpia.de/gulli/geirs/src/branches/cst cst
# cd $CAMHOME ; svn checkout https://svn.mpia.de/gulli/geirs/src/branches/rjm rjm
cd $CAMHOME ; svn checkout https://svn.mpia.de/gulli/geirs/src/trunk trunk
```

- If otherwise the source code is available in a gzipped tar ball, move this into the `CAMHOME` subdirectory of the observer (Linux account) who will start and run GEIRS and eventually generate the FITS files with the data. Prepare for the compilation by unbundling it, and compile the source code:

  ```
  cd $CAMHOME
  unxz -c *_r*.tar.xz | tar x
  cd ... # move into the new _r*M-* source directory to be compiled
  ./INSTALL
  ```

  If you are an inexperienced user or are installing GEIRS on unsupported Linux flavors, save a log file so the installation process can be inspected later on:

  ```
  ./INSTALL &> INSTALL.log
  ```

  This is all done under a generic non-privileged Unix/Linux account. The `INSTALL` script will ask for permissions to modify two binaries that have just been compiled with a sudo(1) command. For test environment where GEIRS runs the data acquistion in simulation mode this is superfluous (and the `INSTALL` requiest may just be cancelled with `CTRL-C`). For production code at the telescope it is recommended to set the permissions to stabilize the real-time behaviour of the data acquistion.[4]

  This needs of the order of five minutes. (This means there is no reason to cheat the installation by copying binaries or setting links or symbolic links between various Unix/Linux accounts.)

  This tar ball and the compilation step is the same for all instruments supported by GEIRS. Note that many links to the `scripts` directory are not installed by this step of the compilation/installation, but at the time when GEIRS is started. (The simple reason is that the scripts that are available should be those depending on the GEIRS version that is run, not on the most recently compiled version.) The decision on which instrument is started/configured is not done at compile time but later at startup time.

The detector patterns are obtained by one (or more) of the following depending on the instrument(s) to be used: [5]

```
cd $CAMHOME/INFO
svn checkout https://svn.mpia.de/gulli/geirs/nirvana/trunk Nirvana # if LN
svn checkout https://svn.mpia.de/gulli/geirs/luci/trunk Luci2 # if LUCI1 or LUCI2
```

[4] Permissions can of course also be set by someone else in the `bin` subdirectory after the `INSTALL`.

[5] Starting in early 2015, the patterns are also in the tar ball and the following can be ignored.

```
ln -s Luci2 Luci # if LUCI1 or LUCI2
ln -s Luci1 Luci # if LUCI1 or LUCI2
svn checkout https://svn.mpia.de/gulli/geirs/panic/trunk Panic # if PANIC
svn checkout https://svn.mpia.de/gulli/geirs/carmenes/trunk Carmenes # if CARMENES
```

There is no public read accesss to this repository. Requests to obtain rights on the repository need to be directed to Florian Briegel at the MPIA. The standard way of distributing the source code is that the GEIRS maintainer (currently the same as the author of this manual) obtains full access to the computer on which GEIRS is run, and installs the software there.

The `OBJECTS` directory is initially empty and may optionally be filled with individual observer's catalogues and serves to speed up Calar Alto telescope pointing operations during a night. This is irrelevant for LBT instruments and CARMENES.

The `MACROS` and `scripts` directories are not under SVN and cannot be obtained that way (and do not need to be obtained that way).

2.3 Compilation

There is only installation support based on the GNU autotools. This works as described in the file `$CAMHOME/`*branch*`/INSTALL` in the source code, which is particularly designed to be copied and pasted into a bash-shell after changing to the installation directory (or to be executed). This contains 16 commands at present and is in general the only thing that needs to be done to upgrade the GEIRS version.

The installation should not be upgraded while GEIRS is running, because some files at common places will be replaced by the versions of the release that is compiled—for the same reason as the one mentioned in Sect. 4.1.

Compile GEIRS separately for each user. Do *not* cross-link binaries from one account to another, because the source code uses static variables and these would be shared if the binaries would be run by the different accounts at the same time (leading to interference effects between the concurrent GEIRS sessions).

The subdirectories `admin` and `devel` are not compiled with a standard installation.

By design, there are GEIRS features that depend on whether the source code is compiled on a computer with a MPIA IP address or not, for example

- The standard logging level is reduced outside MPIA;
- Default IP addresses change;
- Support of handling temperatures and pressures is reduced outside MPIA for instruments other than PANIC.
- Lookup for ROE addresses uses a local name server.

If you are meeting error messages of the type `multiple definition of ‘java resource .dummy’` you are facing a known bug in the `gcc` compiler bundle and need either

- to upgrade to a recent version of the `gcj` package, at least 4.8

- or to install a Oracle JDK (Standard Edition) such that `javac` is in the path,
- or to patch `ecj1` as decribed in my patch.

2.4 De-Installation

Any single GEIRS version suffices to run the instrument.

As with any other software old bugs are removed and occasionally new bugs appear as new versions are developped.

To de-install a GEIRS version remove the entire subdirectory of `$CAMHOME` with the subversioned name, which will be of the format `trunk-r*` or `rjm-r*` or `cst-r*`. If you never want to see it again also remove the associated compressed tar ball.[6] There are no GEIRS specific remnants in the standard system's directories like `/usr`. Versions that are removed disappear from the options for the `start_*_*` and `geirs_start` startup methods.

This is recommended for all versions that have never been used for real-data acquisition at a telescope—to clean up disk space.

2.5 Configuration of the Operating System

2.5.1 Shared Memory

The following paragraph is only of interest if the GEIRS computer is also running competitive programs that use shared memory for their databases and similar purposes.

Under openSUSE or CentOS, the available amount of shared memory is indicated by

```
cat /proc/sys/kernel/shmall
```

or

```
/sbin/sysctl -a | fgrep shm
```

or

```
ipcs -lm
```

As root, this may be momentarily changed by (`sysctl(8)`)

```
sysctl -w kernel.shmall=...
```

To allow this configuration to persist through rebooting the computer, it is recommended to modify `/etc/sysctl.conf` like

```
kernel.shmall = ...

kernel.shmmax = ...
```

`shmmax` is the maximum memory of a single allocatable chunk of shared memory in bytes, and `shmall` is the total allocatable shared memory in units of pages (where a page is typically 4096 bytes as indicated by the output of `getconf PAGE_SIZE` or the number of `shmni` generated above).

[6] This is not recommended for versions that have actually been run in production because one might want to roll back and recompile if for instance the operating system and the drivers or the compiler have been updated.

A full frame of a $2k \times 2k$ chip comprises $4 \times 1024^2 = 4,194,304$ pixels, which amount to $2 \times 4,194,304 = 8,388,608$ bytes with a 16-bit ADC (LUCI,LINC-NIRVANA) or $4 \times 8,388,608 = 33,554,432$ bytes for a mosaic of 4 chips (PANIC) or $2 \times 8,388,608 = 16,777,216$ bytes for a mosaic of 2 chips (CARMENES).

The minimum requirements for the allocatable shared memory is roughly twice these numbers, because the software uses a scheme of two alternating buffers. These values may be taken from the `shmmanager:wanted` lines in the standard output created during startup (Section 3).

A guideline of the shared memory for production where GEIRS runs at most two instruments on the computer at the same time would be half of the total memory available on the machine. These numbers are obtained with

```
cat /proc/meminfo
free
```

under openSUSE or CentOS. The effect is basically a cap on the number of frames that can be swallowed at one time, so it puts limits on the "length" of the sample-up-the ramp modes, on the repetition factors of most modes and the number of pairs of Fowler modes.

2.5.2 Subnet

This subsection is obviously not GEIRS specific but a generic hint to configuration of the host workstation.

If the rack of the ROE electronics are given IP addresses on local networks, the file `/etc/sysconfig/network/ifcfg-e` (typically for openSUSE) on the GEIRS workstation needs to be augmented with the additional subnet(s) and mask(s) by lines of the format[7]

```
IPADDR_ir2='192.*.*.*/*'
# LABEL_...='...'
```

Details depend on how the GEIRS workstation is known to the subnet.[8] This is tested by powering the devices up and `ping`ing the devices from the GEIRS workstation (`ping(1)`). On behalf of GEIRS there is no need to add a nameserver for these devices; working with the 4-byte numerical addresses in the startup-script suffices.

If such entries are missing, GEIRS cannot communicate via Ethernet with these devices.

2.6 User Configuration

2.6.1 Directory Layout

The standard directory layout of the GEIRS installation in the observers file system is a directory named `GEIRS` with subdirectories `CATS`, `INFO`, `MACROS` `OBJECTS`, `log` and `scripts` and a selection of GEIRS versions which have file names that start with `cst`, `rjm`, `hwplx` or `trunk` and end with a SVN revision number.

[7]For PANIC at CAHA this is 192.168.70.1

[8]At MPIA, the IP address is found with `dig +short irws2.ir.lokal @kelu`, `dig +short elablx05.ir.lokal @kelu`. The subnet mask has width 24.

```
GEIRS
   -> CATS/
   -> INFO/
   -> MACROS/
   -> OBJECTS/
   -> cst_r707/
   -> hwplx_r616/
   -> log/
   -> rjm_r718/
   -> rjm_r723M/
   -> scripts/
   -> trunk_r694/
```

Each of the GEIRS versions contains a bundle of C/C++/perl/Java source files and binaries, and directories for the documentation and so on, after the step of Section 2.2 is finished:

```
GEIRS/rjm_r723M
        -> admin/
        -> bin/
        -> caha/
        -> de/
        -> devel/
        -> doc/
        -> share/
        -> test/
        -> *.cxx
        -> *.h
        -> *.pl
        -> Makefile.am
        -> configure.ac
```

Some of the files in such a version are linked back to the `scripts` directory either when the version is compiled or when GEIRS is started. This concept keeps the mandatory executables at a single place (the `scripts` directory) for the benefit of a simple `PATH` variable, but also keeps them synchronized with the operators decision to launch a particular version.

2.6.2 Path

It is well advised to add `${CAMHOME}/scripts` to the path at the standard location; this would be

```
export CAMHOME=$HOME/GEIRS
export PATH=${CAMHOME}/scripts:${PATH}
export MANPATH=${CAMHOME}/man:${MANPATH}
```

in `$HOME/.bash_login` or `$HOME/.bash_profile` (but not both) for the bash(1), for example. Unfortunately there are users who let the environment ignore that setting because they chose their shells not to be login shells—as revealed by the `shopt` command.[9] In these cases the `PATH` must be set in `$HOME/.bashrc` with constructions like

[9]One reason is that the application launcher of openSUSE ignores the files `.Xresources` or `.xinitrc` where one would set the `Xterm*.loginShell` variable. A simple way to improve this is to add the `-ls` option to the

```
if [[ $BASH_SUBSHELL -eq 0 ]] ; then
    export CAMHOME=$HOME/GEIRS ;
    export PATH=${CAMHOME}/scripts:${PATH} ;
    export MANPATH=${CAMHOME}/man:${MANPATH}
fi
```

2.6.3 Standard Scripts

If this is a fresh install, the directory is then populated once with (bash syntax supposed) a set of scripts like `start_carmenes`:

```
mkdir -p ${CAMHOME}/scripts
cd ${CAMHOME}/scripts
for  instr in panic carmenes luci1 luci2 nirva nirvana sc ; do
   for act in start snd cmd ; do
      for v in new old ; do
         ln -s GENERIC ${act}_${instr}_${v} ;
      done;
      ln -s GENERIC ${act}_${instr} ;
   done;
done;
```

If a certain class of users should better not start some of the instruments, delete the associated symbolic link in the `scripts` directory of the user's GEIRS installation; this removes the command from the set of executables of the Linux/Unix account because it disappears from the search list of the `PATH`.

The file `GENERIC` is not just a startup script but a configuration script that defines many of the variables listed in Section 3.2. These defaults *must* be edited at least at two places:

1. If a ROE is to be used such that it is not simulated, `CAMPORT` must be changed to the address of the ROE. Once the instrument is run in a stable environment, the default address is known and compiled into the scripts.
2. The `CAMROE_REV` must be set to the existing pattern directory. This must be done even if the software is used in ROE simulation mode. The default is to use the newest pattern directory installed on the computer.

2.6.4 Shared Memory

Whereas the setup in Section 2.5 allows some maximum of the memory (real and virtual) to be dedicated to shared memory blocks by any applications on the computer, GEIRS needs also to be configured to request some (or all) of this when started. This is done by editing the size of the variable `CAMSHMSZ` in `$CAMHOME/scripts/GENERIC`, likely by setting it to some default of approximately `2048` depending on the name of the workstation. Typically this will be the integer obtained from

`System->Terminal->Xterm` command when editing the openSUSE application launcher with a right-click, and to add that xterm to the Panel.

```
cat /proc/meminfo | fgrep MemTotal
```

divided by 2000—a factor of thousand to transcribe the number of megabytes and a factor of two to respect the needs of other programs with the thread of swapping.

The main effect of this number is to limit the number of frames that can be held in memory for the standard non-continuous readout modes before releasing that space at the time of a `save`.

The `GENERIC` file uses defaults which are slightly dependend on the name of the workstation on which GEIRS is run.

2.6.5 Disk Allocation

There is no automated removal of administrative files by the software. Users need to look into the `$CAMHOME/DATA` directory, the `$CAMTMP` and in particular in `$CAMHOME/log` for obsolete and large log files left behind.

The amount of space required by various log-files depends in particular on the value assigned to `LOG_LEVEL` in `configure.ac` in the source directory. That default level depends on whether the source code is compiled on a computer with MPIA IP address or elsewhere.

Some files grow without bounds, so it is useful to split them into subfiles in regular intervals (with `crontab(1)` for example) one time per day when the instrument is *not* used. A shell script to automate this is proposed in `GEIRS/<branch>/admin/glogRotate.sh`. If

1. `glogRotate.sh` is copied to `$CAMLOG`—where `CAMLOG` is usually `$CAMHOME/log`—,
2. this is made executable with `chmod +x glogRotate.sh`, and if
3. the associated entry as proposed in `glogRotate.sh` is added with `crontab -e` into the schedule of the usual account that runs GEIRS,

this infinite growth of files is limited by the daily growth.

An alternative with a richer set of options is GNU Rot[t]log.

2.6.6 FITS

2.6.7 info

The info file `camera.info` is available which is basically supported by adding also

```
export $CAMHOME=$HOME/GEIRS # assumes default directory layout
export INFOPATH=${INFOPATH}:$(ls -1d $CAMHOME/*/share/info | tail -1)
```

into the `$HOME/.bash_login` such that

```
info camera
```

of `info(1)` will also find the help file of Section 5.3.

2.6.8 Sound Configuration

GEIRS generates sound by playing the audio files in `$CAMHOME/<branch>/admin/*.au` at certain events unless

1. the sound level within GEIRS is set to zero in the `Options` submenue in Figure 6 or with the `sound` command (Section 5.3).
2. the sound is muted with the sound/mixer application on the user's desktop,
3. GEIRS runs on a remote computer and sound is not forwarded to the user's desktop (Section A.3),
4. the environment variable `CAMAUDIOPLAY` was not set (in the startup scripts).

History shows that the people who install GEIRS usually fail to test and install their (remote) sound configuration on the GEIRS workstation, so the sound volume is initially switched to zero for new users to avoid any followup problems.[10] If the setup is not installed properly and sound is switched on (measured according to the criteria listed above), it will likely happen that at the first time a sound is configured to be played, the system call to play that sound will crash, which will trigger a followup error because this will attempt to play `crash.au`, which will not succeed and eventually turn into a recursive endless cascade of sound errors.

The sounds may be changed by replacing the audio files in the GEIRS file system in that directory.

Sound File	triggered by...
doorbell.au	readout finished
cuckoo.au	macro finished
bong.au	backup or the 'shift-and-add' calculation finished
crash.au	general error
fastbusy.au	warning (at changing user level to engineer or if near saturation)
whistle.au	`save` completed
sorrydave.au	unrecognized command
touchtone.0.au	disk full

The executables charged with the sound creation are weakly configurable with the two `CAMAUDIO` environment variables of Section 3.2.

3 INVOCATION

3.1 From workstation or remotely

Call the `$CAMHOME/scripts/start_*` that matches the instrument name, which is `$CAMHOME/scripts/-start_carmenes` for CARMENES. The full path name is not needed, of course, if the environment has been set up as proposed in Section 2.6.

This will create `$HOME/tmp` and `$HOME/DATA` and `$HOME/*.log` if these do not exist. To relocate source, data and logging directories, edit the associated environment variables in `$CAMHOME/scripts/GENERIC`.

The principal ways to control the electronics via GEIRS are

[10]Those problems can be re-introduced if software-engineers just copy GEIRS from one user account to the other; this practise is very bad and entirely discouraged.

1. Interactive manipulation of parameters and exposures with the GUI;

2. Interactive submission of commands with a text interface to the GEIRS "shell" (Figure 10). This interface is richer than the set of GUI buttons because many commands do not have a perfectly equivalent button.

3. Commands sent from the computer on which GEIRS is running from the UNIX/Linux shell with

   `cmd_carmenes` *cmd arguments [; cmd arguments. . .]*

   `snd_carmenes [-s` *server*`[:`*port*`]] [-p` *port*`]` *cmd arguments [; cmd arguments. . .]*

   or

   `cmd_carmenes_new` *cmd arguments [; cmd arguments. . .]*

   `snd_carmenes_new [-s` *server*`[:`*port*`]] [-p` *port*`]` *cmd arguments [; cmd arguments. . .]*

   or

   `cmd_carmenes_old` *cmd arguments [; cmd arguments. . .]*

   `snd_carmenes_old [-s` *server*`[:`*port*`]] [-p` *port*`]` *cmd arguments [; cmd arguments. . .]*

   or

   `geirs_cmdClient [-s` *server*`[:`*port*`]] [-p` *port* `] [-v] [-fi|fc]` *cmd arguments [; cmd arguments. . .]*

   The difference between using or not using the `_new` and `_old` suffixes is that the start script sets the `CAMBIN` environment variable to different subdirectories of `CAMHOME` so one can conviently keep a set of different GEIRS versions in the `CAMHOME` subdirectory.

   The `cmd_` versions connect to the shared memory database of a GEIRS command interpreter running on the local machine; no TCP socket is used—as one may guess from the absence of the corresponding command line options. To this effect it uses the shared memory socket created by the same user in `$CAMTMP` when GEIRS was started; this basically avoids interferences if multiple users are running multiple GEIRS instances on the same computer. For the Luci instruments the standard installation in Section 2.6.3 will create indexed versions `cmd_luci1` and `cmd_luci2` of the command, and this may lead to confusion: because `cmd_` looks up in the user's `~/tmp/shmsocket` to which port to connect, the index of either `cmd_luci1` or `cmd_luci2` does *not* select the instrument. The instrument is the instrument the Linux/Unix user calling the `cmd_` actually started most recently.

   The `snd_` interfaces and `geirs_cmdClient` are essentially the same, where `snd_` calls `geirs_cmdClient` which is based on TCP sockets. `snd_` are shell scripts and supposedly a little slower, but they offer a slightly finer control of which shell variables and GEIRS versions are used while executing a command.

4. Commands sent from a remote computer from the UNIX/Linux shell with

   `geirsCmd [-s` *server*`[:`*port*`]] [-p` *port* `]` *cmd arguments [; cmd arguments. . .]*

   The standard port is 8501 for `geirsCmd` and taken from the port entry in the user's shared memory socket on the *server* for `geirs_cmdClient`.

   Using another port—for example for running multiple instances on the same computer—is supported by starting the `cmdClient` in `GENERIC` either with the switch `-s` *server:port* or with the switch `-p` *port* or modifying the `CAMSERVERPORT` before starting.

   `geirsCmd` uses a TCP socket interface which "represents" the same set of commands as the other interfaces. On the GEIRS computer, the sockets are managed by the `cmdServer`, which is started by either one of the `start*` commands or checking the `-cmd` option in the engineering GUI (Figure 5). `geirsCmd` is indeed just a wrapper which uses that socket interface to submit commands to the `cmdServer`.

The `snd_` versions and the `geirsCmd` both use a socket interface for the command and answer. `snd_` needs an active (=started) GEIRS sessions on the local computer to hook into and uses the port number registered with the shared memory socket at GEIRS startup as a default, whereas `geirsCmd` can contact a GEIRS session running on any remote computer reachable via the network.

5. A Python interface is available which submits all tasks to the `snd_nirvana_new` interface, if the `PYTHONPATH` is set up to include the associated directory for example with

```
export PYTHONPATH=$(geirs_build)/lib/python2.7/site-packages:${PYTHONPATH}
```

in `~/.bash_login` somewhere *after* putting `$CAMHOME/scripts` into the `PATH`.

The invocation is

```
python
>>>import geirs
```

and

```
>>>help(geirs)
```

shows the classes and functionalities which are available (Section 5.8). Alternatively use

```
pydoc geirs
```

6. Any other fundamental socket connection. A `telnet(1)` example looks like

```
mathar@mathar:~> telnet irws2 8501
Trying 149.217.42.24...
Connected to irws2.
Escape character is '^]'.
status
GEIRS_reply_2.0 694
itime: 2.7399310505
cycle-type: lir
cycle-repeat: 1
coadds: 1
ctime: 5.4812006566
last-filename: <unknown_not_yet_saved>
next-filename: trash_0001
autosave: off
...
error: NONE
version: carmenes@irws2: trunk-r737M-7 (May 20 2015, 17:48:39) (SINGLE) (/home/carmenes/GEI
status itime
GEIRS_reply_2.0 20
itime: 2.7399310505
```

```
ctype srr
GEIRS_reply_2.0 3
OK
quit
GEIRS_reply_2.0 56
Command return of 'quit' terminates the camera software
Connection closed by foreign host.
```

The replies contain a header line starting with `GEIRS_reply_` (a version number, a blank, and the number of bytes in the main body, including any line feeds), plus one or more lines in the main body.

Brackets indicate that switches and/or multiple command-argument lists are optional. Quotation marks around the command lists are usually required to avoid that the shell of the operating system splits the lists.

The *server* argument is either a simple name of the workstation on which GEIRS is running (if supported by a DNS) or a plain *tcp://x.y.z.w* IP specification.

If GEIRS has been started without opening the GUIs, inserting `quit` for *cmd* above is the recommended way of shutting GEIRS down.

Note that at GEIRS startup a single (one and only one) command port is activated to which the server listens. The `snd` and `geirsCmd` methods open and close their (client) ports for the duration of their isolated commands. This ensures (to some degree) proper sequentialization of commands and answers. The variety of other possible socket connections to that port will become very confused if a mix of these access methods is used. A standard indicator of that murky situation is that commands do not receive replies because the port is kept open by another client. In short: do @emphnot open the port if it is already used by another client.

3.2 Environment Variables

The following shell environment variables may be set in the `start_*` scripts to configure defaults of the behavior of the software:

CAMERA The master configuration label, which is either `Nirvana`, `Panic`, `Carmenes`, `Luci`, `Luci2`, `Luci1`, or `SIDECAR`. Other names are not supported and obsolete.

CAMHOME The top level directory of GEIRS. It contains at least one `INFO` subdirectory and one `log` subdirectory.

CAMBIN The name of the subdirectory of `$CAMHOME` with the compiled code. This is the `bin` subdirectory of a subversion branch name, like `/GEIRS/hwplx/bin`, `/GEIRS/rjm_r713M/bin` or `/GEIRS/trunk/bin`. Whereas the variable `CAMHOME` usually remains fixed for the operator, `CAMBIN` is chosen as one of these subdirectories when GEIRS is started; this allows switching between different releases of the software. The installation script selects the version with the highest revision number in the `CAMHOME` directory.

CAMINFO A subdirectory for configuration purposes, typically `$CAMHOME/INFO`. The main purpose is to aggregate the pattern (ROE Driver) files prepared in Section 2.2. It also contains bad pixel masks, and `gnuplot` command sequences (Figure 22).

CAMROE_REV The name of a subdirectory of `$CAMINFO` with the patterns to be applied. If the variable is not set, a default is used which is equivalent to the name of the camera, either `Panic`, `Carmenes`, `Luci2`, `Nirvana`, or `Luci1`. There may be more than one of these subdirectories to allow switching between different pattern versions. Examples: `Panic` or `Panic_r74` or `Panic_r76` for PANIC. `Carmenes` or `Carmenes_r5` for CARMENES. `Nirvana` or `Nirvana_r98` for LINC-NIRVANA. `Luci1_r19M` or `Luci2_r20` for LUCI.

CAMTMP The name of the directory for temporary files. If not set explicitly, set to `$TMPDIR`, `$TMP` or `$HOME`/tmp in that order, depending on whether the enviroment variables `TMPDIR` or `TMP` are set.

CAMPORT IP port of the ROE as a string of the tcp://xxx.xxx.xx.xx:4000 format. Empty or not set if there is no ROE rack such that this interface will be used in software simulation. The modification of this address on the ROE side via its interfaces is described in [7, Sec. 4.1.2][8] and Section A.1.

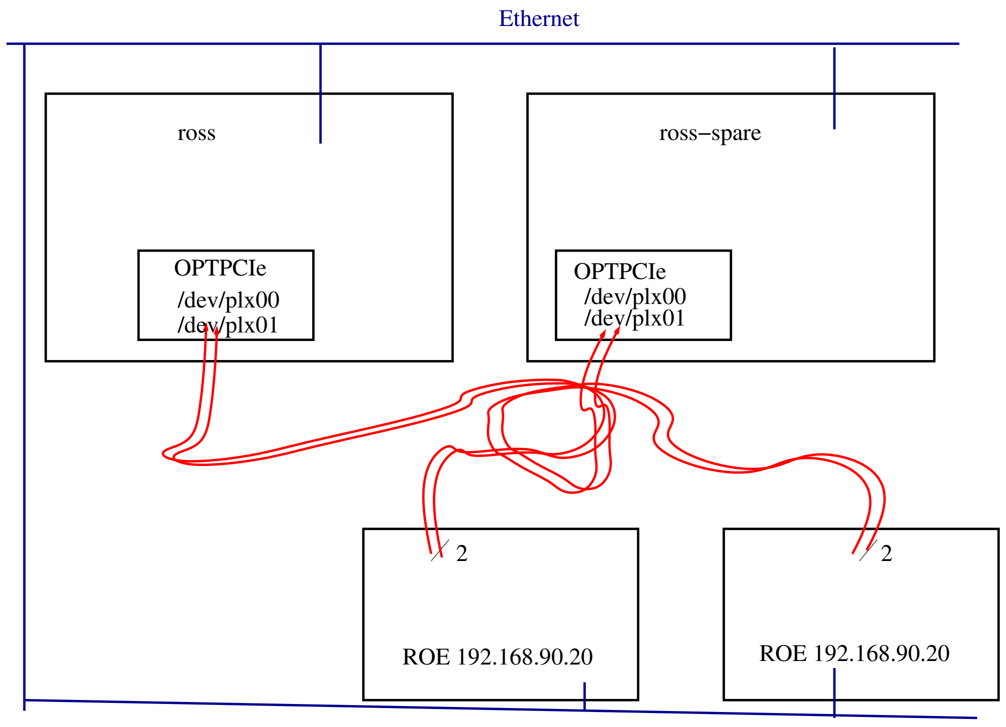


Figure 1: The ROE sends the digitized pixel data of one of the two detector chips through one and the digitized pixel data of the other detector chip through the other fiber of a fiber pair. Each of the two CARMENES computers may receive data from any of the ROE's if GEIRS is configured with the `CAMPORT` variable to talk to the ROE that generates the data and if the fiber that streams the digitized data ends up at the correct OPTPCIe board configured with the `DATAINPORT1` and `DATAINPORT2` variables. The two CARMENES ROE's have the same IP address, which means they must not be used at the same time on the same subnet.

Wherever GEIRS is run, it *must* be able to connect to the ROE that controls the detector via the Internet; the fiber pair from that ROE *must* lead back to the expected OPTPCIe board without swapping the two fiber heads. The fiber connection does not use any sort of network protocol but bare 16-bit data, so it *cannot* work through any type of hubs, routers or switches; it must be *direct* in that sense, allowing only patch panels, ST connectors etc. to cross between laboratories. Note that the `DATAINPORT1` assignments are dynamic: if any

OPTPCIe board is removed from the computer, the remaining one is always addressed as `/dev/plx00`.

If a spare ROE rack is available, there are two options to swap it in:

1. remove the old ROE, modify the IP address of the spare to match the default IP address as instructed in Section A.1, put it into the network,
2. or modify the `CAMPORT` variable to match the new ROE's IP address before starting GEIRS.

Replacement of the ROE rack always requires shutting down and re-starting GEIRS.

DATAINPORT1,DATAINPORT2 Pseudo-device name used by GEIRS to "find" the incoming stream of pixel data on the OPTPCI board. Almost always `plx-00` and `plx-01` unless more than one OPTPCI board are plugged into the computer. The first (left) of the two digits enumerates the OPTPCI boards on the GEIRS worstation starting at 0. The second (the right) of the two digits enumerates the two fibers/DMA channels, 0 or 1. (The physical layer of the data/fiber connections from the ROE to the computer comes always with fiber pairs.) For instruments with only one fiber/DMA channel (Luci, Linc-Nirvana, and PANIC or CARMENES with `CAM_NDET`=1), the second (right) number is always 0, and `DATAINPORT1=/dev/plx?0`. For instruments with two fiber/DMA channels (PANIC with `CAM_NDET=4` and CARMENES with `CAM_NDET=2`), `DATAINPORT1=/dev/plx?0` and `DATAINPORT2=/dev/plx?1`. The software does not support feeding the two fibers of one instrument into two different OPTPCI boards, so the first (left) of the two digits of `DATAINPORT1` and `DATAINPORT2`, represented by the question mark above, needs to be the same.

CAMSERVERPORT IP port number of the command server. The default is 8501 if not set otherwise. After GEIRS startup one can test with a command in the style of

`nc -v -z` *server port*

from the Unix/Linux shell whether GEIRS is actually using that port. The GEIRS server can also be asked with `get CMDIPPORT` what its current port is—but this is not much useful because to submit the `get` to the correct server implies that one already knows the port...).

CAMSTATUSPORT IP port number of the status scanner. The startup script sets the standard port to 8501 for PANIC and CARMENES, to 9501 for LUCI1 and LN, and to 10501 for LUCI2.

CAMSTATUSHOST Name of the host with the status scanner.

CAMSHMSZ Shared memory (in MBytes) reserved for use by GEIRS, see Section 2.6.4. This is roughly aligned with the total available RAM of the host computer via

```
setenv CAMSHMSZ ‘cat /proc/meminfo | fgrep MemTotal | awk ’{printf "%d",$2/2048}’‘
```

in `scripts/GENERIC`. The divisor is basically 1024 (to convert kilo-bytes to mega-bytes) multiplied by some rather arbitrary small factor of the order of 1 or 2. It might be adjusted if concurrent data acquisitions (more than one GEIRS session) are run by multiple users or for multiple ROEs at the same time. This sets an upper limit of the number of frames and images that can be acquired without intermediate `save` operations.

CAM_IDSTR A string generally used in frames of GUIs.

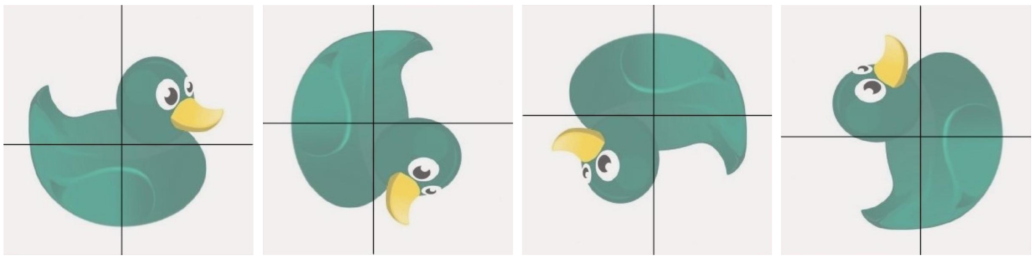


Figure 2: Illustration of the influence of the `CAM_DETROT90` parameter on the image. From left to right: `CAM_DETROT90`=0, `CAM_DETROT90`=1, `CAM_DETROT90`=2, and `CAM_DETROT90`=3, each time in conjunction with `CAM_DETXYFLIP=0` (pure rotations).

CAM_NDET Number of infrared chips, and—with the exception of PANIC and CARMENES—always 1. If the parameter is set to 1 for CARMENES, the GEIRS software will treat the entire readout system as if only the `SCA1` detector were present, triggering only the ADCs on one of the two ROE boards, receiving data only through one of the two fibers, showing only a 2048 × 2048 image and so on.

CAM_ROE_FWSYNC_TLIMIT

CAM_DETROT90 A number from 0 up to 3 (inclusive) to trigger rotations of the detector image by a multiple of 90 degrees to the right. (The fact that these rotations are clockwise is a consequence of GEIRS using a left-handed X11-type coordinate system acting on some internal index tables.) Defining a value of zero is equivalent to not setting the variable at all such that GEIRS falls back to the default of a non-rotated output. This effects both, the views within the engineering GUI's described in this manuscript as well as the pixel distribution in the FITS files. The default for CARMENES is either 1 or 3 to generate a view where the two detector chips are aligned left-right (not up-down). The design of the detector mount allows to re-install the detector rotated by 180°, so whether the standard is 1 or 3 depends (i) on the actual way of detector installation and (ii) on the various opinions of interested parties to flip the wavelength and order axes.

The CARMENES 2-chip layout is special insofar the switch of `DET_ROT90` from 1 to 3 is similar to a swap of the fiber heads (at least if the default of `CAMDPORTS`=2 is used). This cannot be used for a lazy correction of a wrong fiber connection, though, because features like the reset windowing (Section 5.6.1) operate on a dedicatedly enumerated order of the two Hawaii chips: wrong fiber connections let the reset windows appear in the wrong corners of the display and FITS files.

CAM_DETXYFLIP If set to 1, this commands a left/right reflection of the images along the vertical axis. If set to 2, this commands a up/down reflection of the images along the horizontal axis. If not set or set to zero, there is no flip. If set to 3, the two flips are combined and replaced by a rotation of 180 degrees.

In combination with the previous keyword, this supports eight orientations of detector images—the basic mean to obtain a (rough) standard image orientation along N and E in the images (Sect. A.2). Rotations and reflections are not commutative: the rotation will be executed first.

Note that swap of the two fibers that transport the data from the ROE rack to the GEIRS computer (on any of the two sides) *cannot* be replaced or undone by any combination of the **CAM_DETROT90** and/or **CAM_DETXYFLIP** keywords.

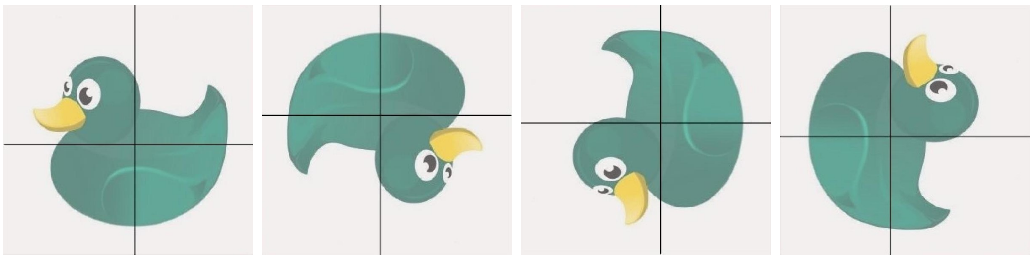


Figure 3: Left: `CAM_DETROT90`=0 and `CAM_DETXYFLIP`=1 (no rotation followed by right-left flip) or `CAM_DETROT90`=2 and `CAM_DETXYFLIP`=2 (180° rotation followed by up-down flip). Second from Left: `CAM_DETROT90`=0 and `CAM_DETXYFLIP`=2 (no rotation followed by up-down flip) or `CAM_DETROT90`=2 and `CAM_DETXYFLIP`=1 (180° rotation followed by right-left flip). Second from Right: `CAM_DETROT90`=1 and `CAM_DETXYFLIP`=1 (90° followed by right-left flip) or `CAM_DETROT90`=3 and `CAM_DETXYFLIP`=2 (270° followed by up-down flip). Right: `CAM_DETROT90`=1 and `CAM_DETXYFLIP`=2 (90° followed by up-down flip) or `CAM_DETROT90`=3 and `CAM_DETXYFLIP`=1 (270° followed by left-right flip).

CAM_BEHIND_DATA Switches on a certain suite of tests whether the amount of 16-bit words received from the ROE exceeds the number expected by the number of pixels and frames.

CAMITIME_MULT Read but not used anywhere.

CAMITIME_PLUS Read but not used anywhere.

CAM_PAT_TIMING Values of 0 or 1 indicate timing analysis with old FPGA electronics (version 2 of the MPIA electronics up to and including LUCI1) or of newer electronics (version 3 and equivalent to all cameras this manual is applicable to).

CAM_MAX_EDTBUFSIZE Defines the size of a single buffer in the ring buffer in units of kilobytes.

CAMDPORTS The number of PCIe channels and fibers set up for the transfer of the ADC data from the ROE. This is 1 for all cameras with a single chip (LINC-NIRVANA and LUCI), 2 for PANIC and for CARMENES. The basic advantage of using two channels (which at the same time implies using both fibers of the connection from the ROE to the computer) is that the data transfer is more stable.[11] If the parameter `CAM_NDET` has been set to 1, GEIRS silently reduces `CAMDPORTS` to a value ≤ 1 if this environmet variable was 2.

CAMREADPARTSZ

CAMEOFCONV Indicates a number of end-of-frame bytes generated by the ROE. Not used nor tested (so the default is zero.)

CAMEOFERR Selects whether errors related to the CAMEOFCONV and/or CAMEOFPCHAN flags are logged as "hard" errors plus messages on the shell or as warnings.

[11]... related to the existance of a 128 kB FIFO on the OPTPCI at the end of each channel/fiber that feeds into the PLX. At a standard readout frame period of 1.3 seconds, the net 16-bit data stream from the ROE to the computer is $4 \times 2 \times 2048^2/1.3$ bytes per second, or 26 MB/sec accumulated by the 4 PANIC chips. With a single 128 kB buffer, the maximum latency of the DMA transfer to the Linux kernel is $128 \times 1024/(26 \times 1024^2)$ sec, or 5 ms. If the data are distributed over both channels, the effective FIFO capacity is 2×128 kB, and the latency allowance is doubled to 10 ms. With the 2 chips of CARMENES, the maximum latencies double to 10 or 20 ms for the counts of channels, espectively.

CAMEOFPCHAN Nonzero values indicate that end-of-frame bytes are inserted by the ROE into the data of each port as check marks to allow some over/underrun tests by GEIRS. This feature is not used nor tested.

CAMMODE Takes influence on the buffering scheme of the shared memory (with a number of buffers then set by the `CAMINTFBUFS` environment variable). Usually not defined, which means defaults to zero.

CAMSERIALEOL_RD Number of end-of-line characters for serial communication with the ROE (reading).

CAMSERIALEOL_WR Number of end-of-line characters for serial communication with the ROE (writing).

CAMSERIALSPEED Baud rate of serial communications with the ROE.

CAMSERIALDELAY Delay between transmission of individual bytes on serial lines.

CAMMOTSERDELAY Delay between transmission of individual bytes on serial lines connected directly (through a line connected to the GEIRS computer) to motors.

CAMBROWSER Full path name to a HTML browser. Only used if the online help is called with the button as in Section 5.3.

CAMWWW The full path name of the HTML help file for use as in Figure 7.

CAMAUDIOPLAY The name and options of the executable that plays the sound files, for example `paplay`, `aplay -d 5 -N -q`, `auplay` or `audioplay`. This specifies the full command stripped off its final parameter (the file name), such that attaching the name of the sound file and redirecting the standard output is a valid system call. See also [9].

CAMAUDIOMIX The name of the mixer of the audio files, for example `aumix`. If the variable is not set, no mixer will be used.

CAMXSERV The name of the X-server. If not set, the value will default to the content of the `DISPLAY` shell environment variable.

MOTPORT Ports for direct communication with the motors (filter wheels etc.). This is a comma-separated list of values, one per MoCon board under GEIRS control. The parameter should be left blank if GEIRS does not control motors. This means it is only relevant to PANIC, which addresses the four filter wheels and the cold stop shutter through the first in this address list.[12]

TELESCOPE The label of the observatory, which is used to set the geographic coordinates and to convert from equatorial to topocentric coordinates. Only a few fixed strings are supported: `LBT`, `CA3.5m`, `CA2.2m`, `Lab`, `GENERIC` and some obsolete others.

TEMPORT Port for direct communication with the temperature and pressure sensors. This is only relevant as a default for the crontab job (i.e., the executable `panictempress` that reads PANIC temperatures and pressures if the command line option `-i` is missing and if the default IP address of CAHA is not to be used. Only relevant to PANIC.

TMOUT If the variable is set and larger than zero, it indicates that GEIRS should shut down if it is idle for that many seconds, which means if no commands are received and no buttons pressed for that duration.

[12]At MPIA, the address is found with `nslookup elotest`.

This list is mentioned for documentation purposes. Not all combinations of cameras and variables are supported or meaningful. In case of doubt it is recommended not to set a variable.

These variables are set in the startup script and exported, so they are defined in the child suprocesses; they are *not* exported "up" to the calling operator's shell—there is no mechanism in Unices for such modification in the other direction.

The generic strategy in the `GENERIC` script is to honor (not to change) variables which are already set when the script is called. This allows users with lesser knowlege of shell scripting to configure/set the variables at other places, for example immediately before calling the script or in the standard files like `.bashrc` or `.bash_login`. Another use of this feature is that one can call GEIRS versions that are older than the most recent three ones or one can invoke pattern versions that are older than the most recent one. Here is an example in the case of LN started from a `bash(1)` shell:

```
export CAMOLD=bintrunk_r657
export CAMROE_REV=Nirvana_r97
start_nirva_old
```

A further aspect is that one can run GEIRS sessions in parallel on the same computer by different Unix/Linux accounts without interference, *if* the communication channels from the observer tool to the GEIRS server and from the GEIRS server to the ROE are kept separate, and *if* the computer is equipped with at least as many OPTPCI boards as active (=non-simulated) ROE's:

```
export CAMSERVERPORT=10501
export CAMPORT=tcp://192.168.0.14:4000
export DATAINPORT1=/dev/plx00
start_luci2_new
export CAMSERVERPORT=9501
export CAMPORT=tcp://192.168.0.24:4000
export DATAINPORT1=/dev/plx10
start_luci1_new
```

(Note that this is *just* an example. Variables will differ for the real instrument depending on hardware configurations!)

In summary: all major parameters are equipped with defaults (which depend on the instrument). If the defaults do not represent the current hardware configuration—because someone changed ROE IP addresses, re-plugged fibers and so on—the GEIRS parameters should be changed either with the Linux shell `export` commands as illustrated above before calling the start script or by modifying them through the startup GUI (Section 4.2.)

3.3 Postprocessing

An infinitely rich interface to post-processing the data, starting pipelines or archival systems is offered by the script or executable located in `QueueFiles` on the GEIRS computer. (The file `QueueFiles` may be anywhere in the `$PATH` but is usually in `$CAMHOME/scripts/QueueFiles`.) It is called at the very end of every `save` command (but not at the end of saving the intermediate frames configured by the `sfdump` command). It receives two parameters, the file name of the file created by that `save` command, and a number indicating the number of files expected to be created by that `save` command. (The latter offers some means to postpone actions in that script for example if GEIRS constructs a series of files with one window per file.) These two parameters are available in the script as `$1` and `$2` in the common Unix/Linux shells, or in the `argv` vector of higher programming languages if one would replace the shell script by any binaries.

The features of that architecture are:

- At the point in time when `QueueFiles` is called, the FITS files are already closed. So instead of polling the status of the crep counter or any similar status variable, or polling the file system for any new files that arrive, it is safer and less disruptive to trigger pipeline actions by adding them to the script.
- The `save` command is finished when `QueueFiles` terminates. If foreground commands in `QueueFiles` hang, `save` does not terminate—which might lead to the wrong conclusion that GEIRS hangs whereas it actually waits.
- As already said, `QueueFiles` is called synchronously with the `save`. Within this script, however, further actions may be pushed into background processes such that they are effectively becoming asynchronous to the GEIRS processing.
- The `sync` and `sync save` command wait on the `save` command, so the delay depends implicitly on the timing chosen within the `QueueFiles`.
- The `QueueFiles` must be a valid script and of course be executable as usual in the Unix/Linux sense. It may be empty—aside from comments etc.—if there is nothing to be done.
- There is only one `QueueFiles`. If instrument pipelines or monitors need variable actions depending on other than the two variables forwarded as command line arguments, they either need to edit/move/remove the `QueueFiles` dynamically—cautiously synchronized with the `save`—, or gather more information from the shell or user environment and use standard branching/switching statements of the shell.

Examples of actions in the `QueueFiles` are ds9 calls (Section 4.3.3) or examination of test files with the script in `test/QueueFiles` of the source directory. **Panic!** uses this file to add CAHA ambient data to the place where forthcoming `save` processes pick up additional FITS information.[13]

This interface is a specialized (by time and place of the invocation) call to the operating system. The `system` command (Section 5) to the shell offers the more flexible and general interface.

[13] An equivalent action for CARMENES was removed for CARMENES in r748 because this needs to be done via a `wget` call on their infrared computer which turned out to introduce more jitter in the timing than accepted by the instrument team.

4 GRAPHICAL USER INTERFACE (GUI)

The software handles all infrared cameras at Calar Alto. Therefore the observer, once having used one system, will easily feel at home with the other cameras. Changes are introduced only due to different hardware. The aspects of GEIRS working as

1. a telescope control interface,
2. a motor control interface,
3. a temperature/pressure monitoring system

are partially disabled or virtualized in the Carmenes configuration.

4.1 Start-up (Standard)

It is useful to check with

```
ps -C geirs_shmmanager
```

whether someone else is already running GEIRS on the machine. Then the command

`start_carmenes` *[-iwin] [-gui] [-disp] [-cmd]*

respectively

`start_carmenes_old` *[-iwin] [-gui] [-disp] [-cmd]*

or for the most recent version of the software

`start_carmenes_new` *[-iwin] [-gui] [-disp] [-cmd]*

starts GEIRS. If no command line option is used, all four of them are implicitly activated. If the `-iwin` option was present (explicitly or implicitly), it commences with the start-up screen of Figure 4. The controls and/or the image GUI will be opened depending on the presence of the options `-gui` and/or `-disp`. The command server is started depending on the presence of the option `-cmd`. The `-gui` option works only if the command server is either started here or already running.

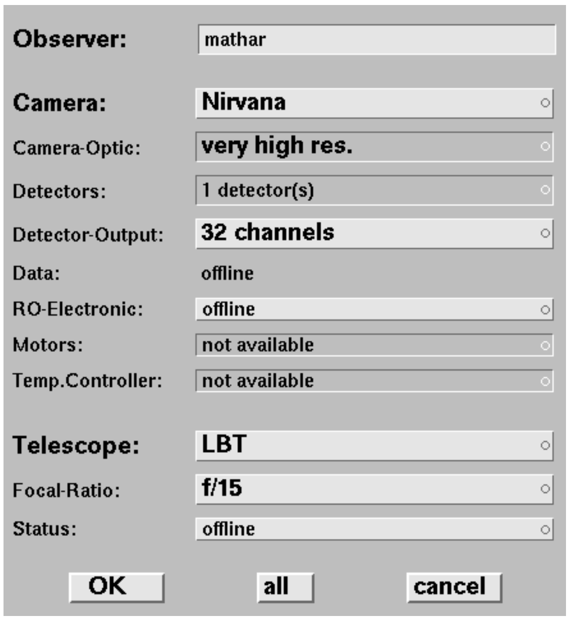
Error messages of the "Command not found" class indicate that the software may not have been compiled, installed or simply not integrated into the `PATH` of the operating system.

The start commands refuse to start GEIRS if the associated TCP port is already in use.

The startup script may replace some files at common places (like in the `scripts` or `INFO` directories) by versions that depend on the GEIRS version that just has been called. It generally does this by managing symbolic links. The only reason for this breaking of the rules of versioning is that some other softwares (drivers that access GEIRS from the outside) expect to find them at fixed locations in the directories.

In the associated shell script, a set of configuration decisions have already been made. Most of the screen shots of this manuscript show the result of setting `CAMFONT` to `helvetica` in `scripts/GENERIC`, for example.

The startup script shows the remaining disk file capacity on the initial FITS file directory. The guideline is that readout electronics, detectors and fiber channels inbound via the OPTPCI boards



Observer:	mathar
Camera:	Nirvana
Camera-Optic:	very high res.
Detectors:	1 detector(s)
Detector-Output:	32 channels
Data:	offline
RO-Electronic:	offline
Motors:	not available
Temp.Controller:	not available
Telescope:	LBT
Focal-Ratio:	f/15
Status:	offline

Figure 4: Startup screen to start GEIRS.

are *not* shareable resources. The number of GEIRS instances running in simulation is not limited (apart from details mentioned elsewhere), but the number of GEIRS instances handling any real ROE or OPTPCI board at a time must never be larger than one. To that purpose, the startup script runs once `geirs_cleanup` with a test flag, which detects GEIRS processes already running by this or other users on this computer (see Section 5.5). On a system similar to LUCI with two GEIRS instances possibly running in parallel, don't be alarmed if some GEIRS linux processes pop up here, because this may be the handler of the other arm of the telescope! In the standard case of running GEIRS for PANIC, CARMENES or LN with a telescope, GEIRS processes should not appear in the list—anything else means that either

1. local policies of properly shutting down GEIRS have not been communicated well between observers, or
2. the previous shutdown of GEIRS did not run smoothly. In that case running `geirs_cleanup`—without the `-t` option—may be useful to clean up these residuals, before trying again to start GEIRS.

Some parameters may be edited in Figure 4 at this time:

- **Observer** Enter your name as observer. This will (i) appear in the FITS files and (ii) toggle allowances for some commands reserved for engineering purposes. (See Section 5).
- **Camera** This is a fixed entry here, derived from the name of the startup command.
- **Camera-Optic** This is fixed here, because the optical elements are not changing properties as far as GEIRS is concerned.
- **Detectors** The number of detector infrared chips is fixed here.
- **Detector-Output** The number of channels used in parallel to shuffle the read-out data through the ADC chain. This degree of parallelism has major influence on timing and on the

interlacing of data that arrive on the computer via the fiber links. Luckily, this configuration is also fixed here. (32 channels are announced here; data of the four additional ADC's of the AD36 are not transferred.)

- **Data** Defines through which bus of the operating system the software expects data. Operation through as many different PCIe boards as the computer hardware allows interfacing to a set of different ROE electronic boxes. Details depend on the slot assignment on the host computer. The names `/dev/plx-??` are used for historical reasons. They do not correspond to UNIX/Linux devices in the file system (which appear as `/dev/plx/Plx*` if installed as described above). The first placeholder in the name is `0` or larger if more than one OPTPCI board is installed. The second placeholder is `0`, and may be also `1` if the ADC data from the ROE are also sent in parallel via the second data port.

  If this is `offline`, the software will assume a ROE simulation mode. The two stages of simulation of data by the pattern generators of the control electronics (without detector) are then not available either.

- **RO-Electronic** Setting this to `offline` will start the software in a simulation mode. Otherwise it is the TCP socket and port for the communication with the ROE. If the data generator of the `OPTPCI` board in the computer will be used for test purposes described in [5], but if no ROE rack is available or if this rack is switched off, some fake address of a non-responding computer should be inserted here.

  In the *simulation* mode, GEIRS produces fake images and FITS files by placing spots at randomized positions across all detector chips in the field mimicking a seeing close to one arcsecond. It does *not* try to communicate with the ROE via the network or to receive image data through the fibers. The positions are randomly selected for each of the images; they are not drawn from any star catalog.

  In the simulation mode, the pointing direction is randomly selected from zenith angles between 0 and 60 degrees and no preference in azimuths.

- **Motors** Irrelevant, because GEIRS does not control CARMENES motors.

- **Temp.Controller** Irrelevant, because temperatures are neither controlled nor monitored by GEIRS for this instrument.

- **Telescope** This entry is fixed, and triggers a selection of geo-positioning data of the observatory that end up as FITS header cards and UT/ST converter parameters in the telescope control GUI.

- **Focal-Ratio** This entry is fixed, and only effects writing a FITS header keyword.

- **Status** This is always `offline`, because GEIRS does not communicate with the telescope controls. The virtual pointing and catalog operations described further down are nevertheless enabled.

The defaults are read from the file `$CAMTMP/CAMDEFAULTS` which was created by GEIRS during the most recent shutdown.

The small symbols to the right end of these fields indicate a type of action:

- Circles are multiple choice selectors

- Down-triangles are scroll-down menus

- Squares are buttons that toggle binary values changing to green if activated
- Right- or left-triangles are incrementors or decrementors of an editable field
- No such symbol appears for push buttons or text entry fields.
- Asterisks announce opening of additional standalone GUIs. Presence (absence) of the asterisk shows whether the window will be closed (opened) if the button is pressed.

After you press `all` Figure 4, the subsystems (most noticably the ROE) are initialized and the GEIRS window of Figure 6 will appear. At that time all (recent) instrument patterns send commands to the ROE which switch most of the ROE's LED's off. The LED's of the network card of the ROE cannot manipulated by these software means (and must be taped to shield their light).

The button `OK` compares the current parameters of the command server with the parameters proposed in the GUI and skips the initialization if the two sets are the same.

Actually both the "Controls" window (Figure 6) and the main display window (Figure 15) may be suppressed by removing the `-gui` and the `-disp` options, respectively, from the call of the `shell` in the `$CAMHOME/scripts/GENERIC` script. These changes in the configuration are available if the instrument is run in a stable production mode where the pipeline investigates the FITS files that are produced, such that the quick look at the frames is not needed or replaced by the more common ds9 viewer.

If some subsystems of GEIRS, like the ROE, the Motors or the Telescope are set or left in a `not available` or `offline` state in Figure 4, some parts of the GUIs described in this manual display yellow diagonal crosses to provide a visual warning that the corresponding section of the action or information is in some state of software emulation/simulation.

4.2 Start-up (Engineering)

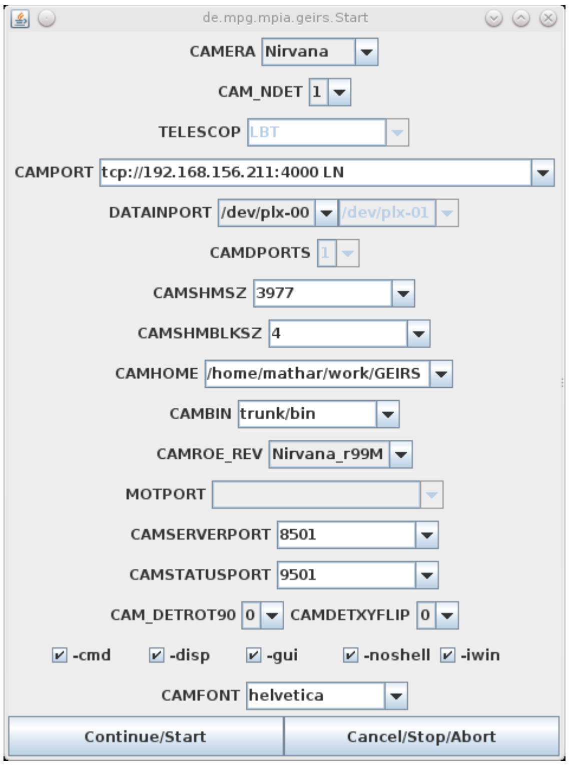
Alternatively there is an engineering GUI called by

```
geirs_start
```

which opens up similar to Figure 5. (The GUI is not available on systems where neither the `gcj` compiler nor the Oracle Java compiler was found at compilation time.) This allows *experienced* users to edit many parameters on a finer level without editing the `GENERIC` script, but at a higher risk of starting GEIRS with modes that are not supported. The program scans a fixed list of ROE IP addresses and puts those that seem to be online into the selector for the `CAMPORT`. It puts subdirectories of `CAMHOME` that look like compiled GEIRS versions into the `CAMBIN` selector. If the `Continue/Start` button is pressed, the program sets some of the environment variables mentioned in Section 3; labels in the GUI and environment variables correspond to each other. Then it calls the shell script `scripts/GENERIC` with the options set in the third but last line of Figure 5. The principal rationale for having this GUI is that one can

1. mix hybrid instrument configurations as they frequently occur in the MPIA development process.
2. swich temporarily to a configuration without editing the `GENERIC` script.

The major drawback of starting with this GUI is that none of the confirming messages do appear on standard output as they do with the `start*` scripts mentioned above.



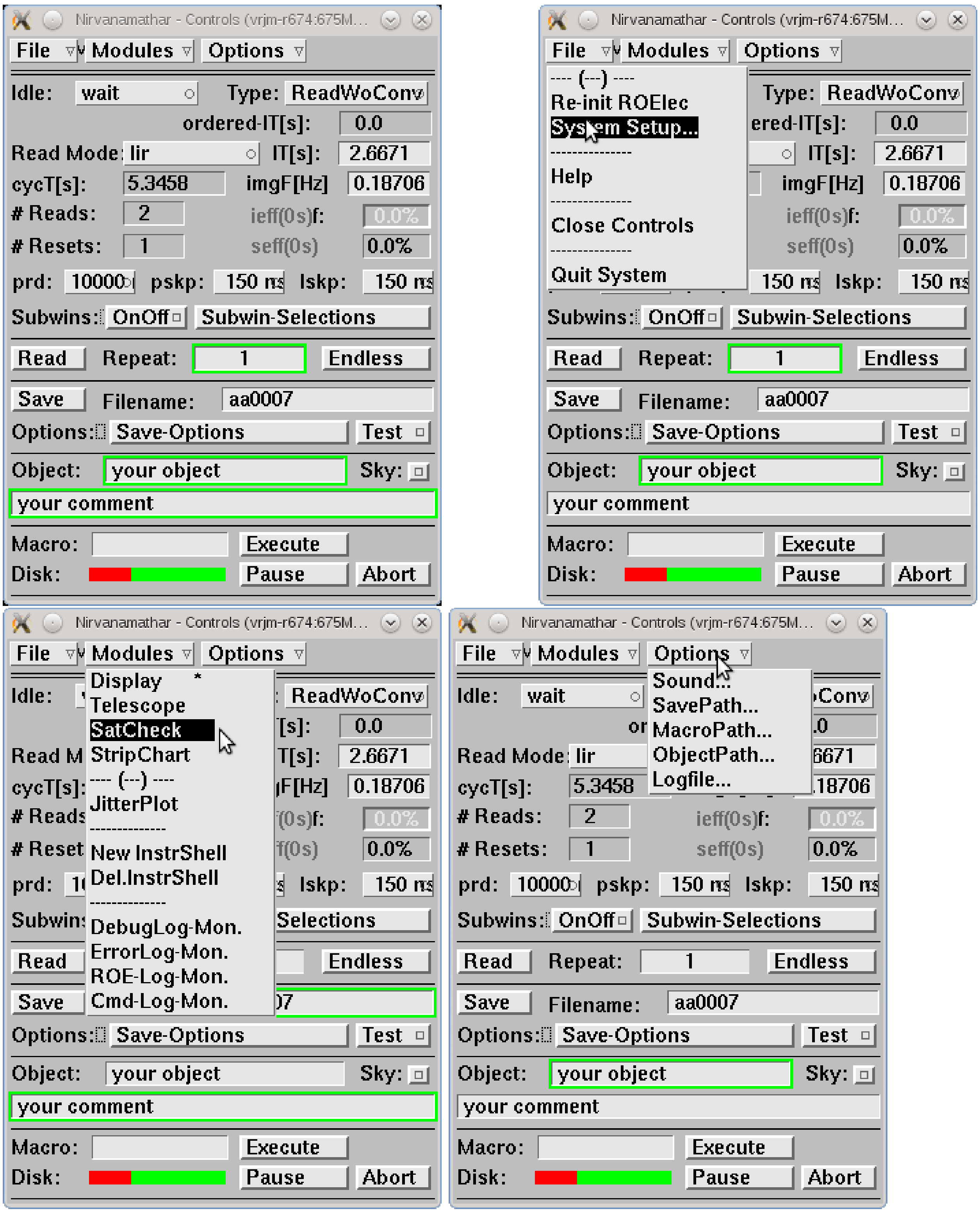
CAMERA Nirvana
CAM_NDET 1
TELESCOP LBT
CAMPORT tcp://192.168.156.211:4000 LN
DATAINPORT /dev/plx-00 /dev/plx-01
CAMDPORTS 1
CAMSHMSZ 3977
CAMSHMBLKSZ 4
CAMHOME /home/mathar/work/GEIRS
CAMBIN trunk/bin
CAMROE_REV Nirvana_r99M
MOTPORT
CAMSERVERPORT 8501
CAMSTATUSPORT 9501
CAM_DETROT90 0 CAMDETXYFLIP 0
✓ -cmd ✓ -disp ✓ -gui ✓ -noshell ✓ -iwin
CAMFONT helvetica

Figure 5: Engineering startup with `geirs_start`.

4.3 The GUI's windows

4.3.1 Camera control window

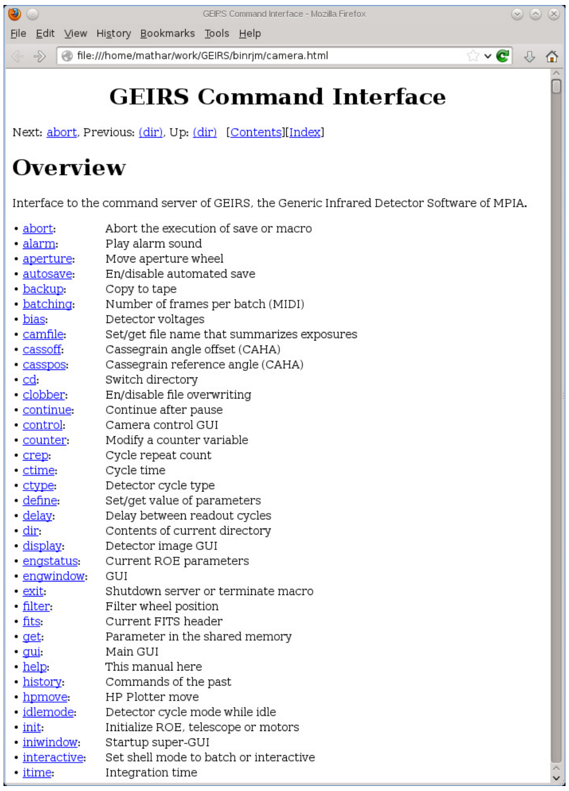
The control window of Figure 6 is the interactive interface to the camera. Fields are changed by clicking into them, which produces a green frame around the field. (The GEIRS GUIs are build on the low-level X11 library. This means that any triggers by `mouse-over` or similar events, or size modifications by dragging edges or corners that modern desktop environment configurations offer are not available.) However, editing in the fields is not possible. You always have to type your text anew, which intermediately changes the background to red, and finish editing by pressing `Enter`. In the top row three pull-down menus provide further options:



Idle: wait Type: ReadWoConv
ordered-IT[s]: 0.0
Read Mode: lir IT[s]: 2.6671
cycT[s]: 5.3458 imgF[Hz] 0.18706
Reads: 2 ieff(0s)f: 0.0%
Resets: 1 seff(0s) 0.0%
prd: 10000 pskp: 150 ms lskp: 150 ms
Subwins: OnOff
Repeat: 1
Filename: aa0007
Options:
Object: your object Sky:
your comment
Macro:
Disk:

Figure 6: The camera control window with its drop-down menus.

- File Menu
  - **Re-init ROElec** resets the read-out electronics
  - **System Setup** will bring up the initialization window of Figure 4.
  - **Help** Opens a web browser which shows a HTML version of the command list, similar to Figure 7, equivalent to the contents of Section 5.3. This will fail if the environment


GEIRS Command Interface - Mozilla Firefox
File Edit View History Bookmarks Tools Help
file:///home/mathar/work/GEIRS/binrjm/camera.html

GEIRS Command Interface

Next: abort, Previous: (dir), Up: (dir) [Contents][Index]

Overview

Interface to the command server of GEIRS, the Generic Infrared Detector Software of MPIA.

• abort:	Abort the execution of save or macro
• alarm:	Play alarm sound
• aperture:	Move aperture wheel
• autosave:	En/disable automated save
• backup:	Copy to tape
• batching:	Number of frames per batch (MIDI)
• bias:	Detector voltages
• camfile:	Set/get file name that summarizes exposures
• cassoff:	Cassegrain angle offset (CAHA)
• casspos:	Cassegrain reference angle (CAHA)
• cd:	Switch directory
• clobber:	En/disable file overwriting
• continue:	Continue after pause
• control:	Camera control GUI
• counter:	Modify a counter variable
• crep:	Cycle repeat count
• ctime:	Cycle time
• ctype:	Detector cycle type
• define:	Set/get value of parameters
• delay:	Delay between readout cycles
• dir:	Contents of current directory
• display:	Detector image GUI
• engstatus:	Current ROE parameters
• engwindow:	GUI
• exit:	Shutdown server or terminate macro
• filter:	Filter wheel position
• fits:	Current FITS header
• get:	Parameter in the shared memory
• gui:	Main GUI
• help:	This manual here
• history:	Commands of the past
• hpmove:	HP Plotter move
• idlemode:	Detector cycle mode while idle
• init:	Initialize ROE, telescope or motors
• iniwindow:	Startup super-GUI
• interactive:	Set shell mode to batch or interactive
• itime:	Integration time

Figure 7: The web browser called by the `Help` button in Figure 6.

  variables `CAMWWW` and/or `CAMBROWSER` of Section 3.2 are not configured correctly.
  - **Close Controls** Closes the window of Figure 6. Use this if *and only if* you are either knowledgeable of how to re-open the window or never want to see it again.
  - **Shutdown GEIRS** will close GUI's related to the session and terminate the command server and shared memory manager. It is equivalent to the `quit` command (Section 5.3). This is a swift and recommended way of terminating GEIRS.
- Modules Menu The modules menu starts the different modules, each of which has its own description section.
  - **Display**: Toggles the status of the image display, Figure 15, i.e., starts it if not shown and closes it if shown.
  - **Telescope** Telescope control. Only available for PANIC.
  - **SatCheck** Turns on audible saturation warning.
  - **TempControl** Displays a graph with the pressure and various temperatures inside the dewar This button is only present if the `CAMWOTPCTRL` is not set in the environment (that is, in the shell script to start the instrument). The display is passive in the sense that they show a scan of lines in a special format taken from a log file that is typically fed

by a `cron(5)` job which reads the sensors . GEIRS does not need to be online to store these. The plot may even be displayed with

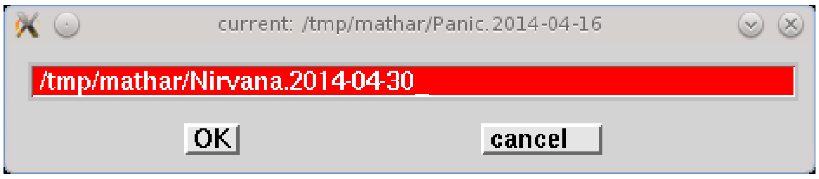
```
cd GEIRS/INFO ; xterm -e gnuplot tmp_gp.panic
```

if GEIRS is not started.
Irrelevant in the case of LBT instruments or CARMENES which have dedicated subsystems to deal with these house keeping data.

- **JitterPlot** shows statistics of the frame arrival time jitters, Section 4.3.6.
- **New InstrShell** Opens a instrument shell window similar to Figure 10.
- **Del. InstrShell** Closes the instrument shell window.
- **DebugLog-Mon.** Opens a debug log monitor similar to Figure 11.
- **ErrorLog-Mon.** Opens an error log monitor similar to Figure 12.
- **ROE-Log-Mon.** Opens a log monitor similar to Figure 13 showing a history of command exchange with the ROE.
- **Cmd-Log-Mon.** Opens a log monitor similar to Figure 14.

• Options Menu

- **Sound** calls up a sound menu, where a specific sound file can be associated with a variety of different events (such as telescope moves, completion of a read ...).
- **Savepath**, `Macropath`, and `Objectpath` are directories that tell GEIRS where to save FITS data and where to look for macro and object (astronomer's pointing coordinate) files.
  `Macropath`, the default search path for GEIRS macros, is usually set to the `MACROS` subdirectory in `$CAMHOME`.
  A default for the `CAMPATH` is proposed which is derived from the current value of the directory by replacing the lowest component with the instrument name and an ISO time stamp of the current date (Figure 8). Pressing `cancel` keeps the current value—which is shown in the title bar of the GUI. Editing the path name and pressing `ok` or carriage-return may pop up another window which asks to create the directory.


current: /tmp/mathar/Panic.2014-04-16

/tmp/mathar/Nirvana.2014-04-30_

Figure 8: Popup after Selecting `Options`→`SavePath...` in the Controls GUI of Figure 6.

  At the time when GEIRS is shut down, the values are stored in the files `CAMPATH`, `CAMMACROS` and `CAMOBJECTS` in the `$CAMTMP` directory, and retrieved from there at the next startup.
- **Logfile** specifies where the log file is kept.

Below the drop-down menus various fields display the status of the camera and allow the setup to be changed:

• **Read setup**

- **Idle** This parameter defines whether the transition from the idle mode to the read mode is done
  - abruptly (`break`, with a sort of immediate termination or break of the idle cycle) or
  - whether the currently running idle cycle is completed before the `read` starts (`wait`, reaching first a type of break point at the end of the idle cycle before switching to the read mode).

  Using `break` has the advantage of starting the reading with the least possible overhead, but it usually leads to visible edge effects in the next frames because the clocking through the detector was interrupted at some position along the “slow” direction. For this reason this parameter defaults to `wait` for all instruments. There is an intermediate type called `auto` which is equivalent to `wait` for integration times shorter than some configurable threshold and to `break` for longer integration times. The associated command is `idlemode` in Section 5.3.
- **Idle Type** The idle mode is the (usually periodic) pattern of voltages applied to the detector lines (reading and resetting) while the ROE’s ADC’s are switched off such that no data are actually transferred via the fibers to the workstation. GEIRS supports four choices:
  1. `ReadWoConv` (Read without conversion) Reads and resets execute the same timing pattern as in the read mode. The cycle time of these idle cycles is the same as the main mode, including the prolongations by any integration times; this aspect plays a major role if the `Idle` button has been switched to `wait`.
  2. `Lir` (Line interlaced read) A cyclic repetition of the read-reset-read pattern at the minimum integration time (which means, the integration time implied by clocking once through the detector at the current pixel time).
  3. `Rlr` (Reset level read) Resets then reads the detector line by line. There is a single read of each pixel in this idle pattern, so this is basically clocking once through the chips in half the time relative to the `Lir` idle mode.
  4. `Reset` (Reset only) Executes a series of resets.[14] No reads are involved and therefore these idle mode cycles are the quickest available.

  With the exception of PANIC the default is `Lir` for all instruments. The idle patterns are unaware of any of the three possible subwindow sets of the current read mode (Section 5.6.1), which means timing and resets in the idle cycles are equivalent to full frame handling of all chips. The associated command is `idlemode` in Section 5.3.
- **Read Mode** The different read modes available are described in detail elsewhere [6]. For standard broad band observing this should normally be left at the initial default of the instrument (which is `lir` for LN). The GUI sends a `ctype` command of Section 5 to the command/interpreter shell.
- **IT(s)** is the integration time in seconds. The detector is clocked with a rate of 100 kHz, resulting in a minimum integration time of

  $$\frac{2048 \times 2048\,\text{pixels}}{32\,\text{channels}} \times \frac{2\,\text{frames}}{100\,\text{kHz}} = 2.7\,\text{sec} \tag{1}$$

  in full-frame mode that reads two frames, this accumulates 2.7 sec like in Figure 6.
- **cycT[s]** is the total time for one read cycle in seconds.
- **# Read / # Resets** is the number of reads and resets executed in the current read cycle.

[14]full frame or line by line, I cannot tell. . . RJM 2015-08-03

- **ieff(elapse time)** gives the observing efficiency as the ratio of integration time to cycle period.
- **seff(elapse time)** gives the system efficiency as the ratio of time for read-out to elapse time.
- **Repeat** is the number of images N with the specified exposure time T which will be taken each time a read is executed (read-cycle). The total exposure time will then be $N \times T$ seconds. The maximum number of images depends on the computer shared memory set up in Section 2.5 and the setting of `CAMSHMSZ` in `scripts/GENERIC`. The current sequence number of the `reads` is displayed to the left (`Read` button, see below). `Endless` may be pressed to start an endless loop of reads. The images are read out with the current integration time and dumped to the display. They are not saved unless the `autosave` option has been activated via the GUI (Figure 9) or `autosave` command (Section 5.3). This is useful for positioning the telescope before e.g. starting a macro.
- **Read** The read button executes a read using the current exposure time and number of repeats. On completion of a read, the images are not saved unless `autosave` is selected under the save option. While the ROE is reset—for example explicitly with the `Re-init ROElec` menue or implicitly while a new `srre` pattern is uploaded—the label on the button changes from `Read` to `R:`. The button is disabled while an exposure is executed.
- **Save** The save button saves the most recent image(s) obtained using the currently defined save options.
- **Filename** The name of the next file to be saved by pressing the `Save` button at the beginning of this line or by issuing a save-command from a script. One can either specify a name or a root. In the latter case the filename is the root plus a four digit integer, which will be automatically increment by one each time a save is executed. By specifying the root, the system looks for the highest free filename. If a filename ends with a number this number will be increased.
- **Save-Options** Calls up a save configuration panel, Figure 9, which defines the default way in which to save images. The file name to be created next is defaulted. The range of frames to be saved follows in the next line of options. The `area` is the data section in pixels, in 1-based FITS coordinates—equivalent to having defined one software window. The main choices are whether
  - to save individual exposures as separate disk files, equivalent not to activating any of the push buttons;
  - **integrated** to integrate them (add them up arithmetically) and save only a single image;
  - **FITS-cube** to store the individual frames as layers following the 3-dimensional FITS cube standard;
  - **MEF** to add the `-M` option to the `save` command and end up with the multi-extension FITS format, were images and subwindows are stored as FITS extensions, one extension per window
  - **FITS compr.** to use the “internal” tile compression registered as a convention of the FITS standard [10, 11].
  - **dif-intf** No longer supported.
  - **sngle frms** to add the `-S` option to the save command, which puts the individual frames into the FITS files, not the pre-correlated/preprocessed images.
  - **auto-save** to save the data automatically (without waiting for a request through a `save` via command shell or GUI)

∗ **immed.-save** to save the data as soon as reading a frame is completed. (The difference to the `auto-save` is not waiting for macro termination and even starting the disk transfer before saving the previous frame has finished—used for the `dif-intf`.)

Note that the save options are overridden by any options specified in observing macros. For example `save -f 2 -i` in a macro will integrate from image 2 to the end of the

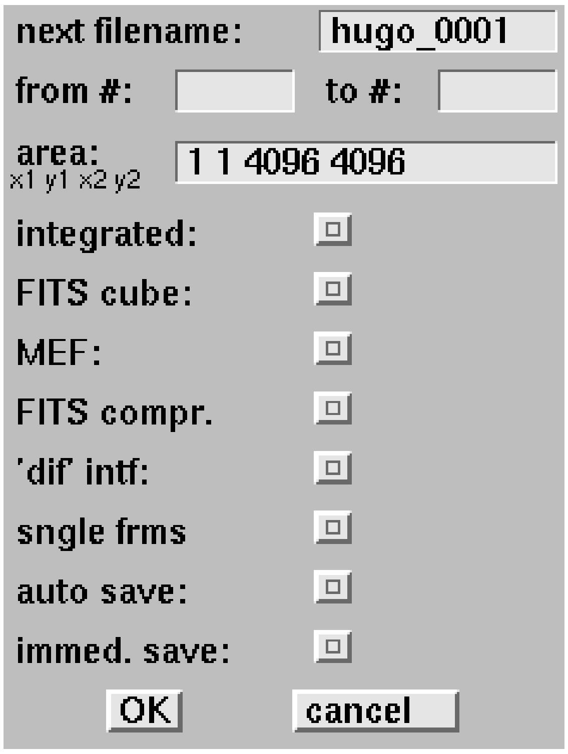

next filename: hugo_0001
from #: to #:
area: x1 y1 x2 y2 1 1 4096 4096
integrated:
FITS cube:
MEF:
FITS compr.
'dif' intf:
sngle frms
auto save:
immed. save:

Figure 9: Save options window

series, and save only a single file, even if the save options specify saving images separately. Turning on auto-save will execute a save after every read, without clicking on the save button.

– **Test** indicates that not the current parameter of the `Filename` is the root name for the next image, but simply `test`. After the test exposure the previous file / root name is restored (unless `Test` is activated again). The purpose is to separate one-time test exposures and a stream of regular exposures easily by file name in the directory of the operating system.

– **Object** is the object name which is written into the FITS header under the keyword `OBJECT` for the current image. It will be updated automatically if object selection is done through object files (recommended), or can be changed by hand.

– **Sky** Clicking on the sky button writes a sky flag into the FITS header, but otherwise has no effect.

– **Comment** to be included in the FITS-header.

– **Macro** Specifies a macro (file with a list of GEIRS shell commands) to be executed by the macro parser. If the filename has the (recommended) suffix `.mac`, the filename may be specified without the `.mac` extension. The macro file must be in the `MACROS` directory specified under the macro path in the options menu (see above) or otherwise be specified by the full path name. Please refer to Section 5 for the macro syntax and commands.

Specification of the macro just provides the file name; the macro is not started yet but with the button right to the entry field.

– **Execute**, **Pause**, and **Abort** control the execution of observing macros, reads and running programs. Note, that if a pause or abort is issued, the macro will continue executing until the current command is completed! Check in the command window to be sure that the pause is in effect. Clicking on continue will continue executing the macro after the pause.

  While the macro runs, the `Execute` button turns yellow with an indication of how many percent of the command lines (including debris like comments, blank lines and so on) in the macro file have already been executed.

– **Disk** The green portion of the bar indicates the fraction of the selected disk which is still available. The GUI issues an audible warning when the disk is getting close to full (assuming you have not turned off the sounds!).

If the GUI of Figure 6 disappeared, it can be reconstructed with the `control` command to the GEIRS shell (Section 5) or using the equivalent forwarding with `cmd*` or `snd*` (Section 3.1) from the Linux shell.

4.3.2 Command Shell and Log Monitors

The `Modules`→`New InstrShell` menu starts the interactive command shell interpreter of Figure 10. The window can be closed with the `Modules`→`Del InstrShell` button.

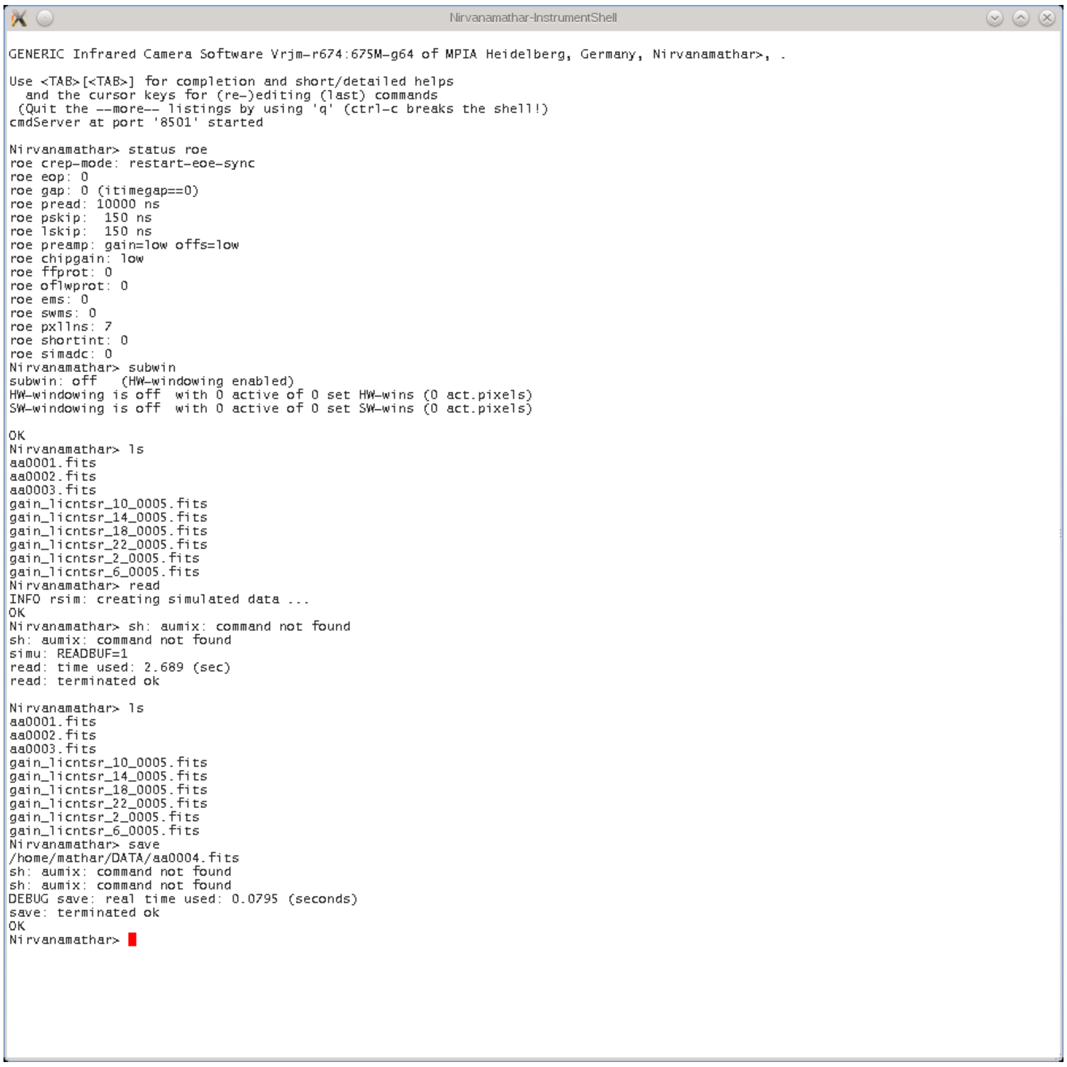
The appearance of the Command Shell and logging windows (sizes, colors,. . .) is defaulted as for X-terminals as set at the standard places in the file system, `$HOME.Xdefaults`, `$HOME/app-defaults` etc.

After the prompt, the GEIRS command shell expects commands from the list reproduced in Section 5, and the terminal echos the responses. The commands send from this window and the commands created by pushing buttons in Figure 6 are received by the same command manager and effect only one single set of state variables. Both channels may be used at the same time.

Four additional log monitors may be opened with the `Modules` menu, illustrated in Figures 11–14. These are passive displays: they filter lines from the `$CAMHOME/log/*.log` files; the logging parameters and amount of information that is stored in these files does not depend on whether the associated GUI is open or not. (The logging information *does* depend on the `LOG_LEVEL` definition in the `GNUmakefile` while compiling and further on the adjustments by any `log` commands send to the GEIRS shell.)

The monitor of the debugging logs, Figure 11, shows

- a time stamp (local time zone of the operating system),
- the user name on the host machine,
- a (failed, due to the failure of SVN to report a version of the software if the SVN repositories are migrated) attempt to show a source code revision number,
- the file and line number in the source code,
- the function in the source code,



```
GENERIC Infrared Camera Software Vrjm-r674:675M-g64 of MPIA Heidelberg, Germany, Nirvanamathar>, .

Use <TAB>[<TAB>] for completion and short/detailed helps
  and the cursor keys for (re-)editing (last) commands
 (Quit the --more-- listings by using 'q' (ctrl-c breaks the shell!)
cmdServer at port '8501' started

Nirvanamathar> status roe
roe crep-mode: restart-eoe-sync
roe eop: 0
roe gap: 0 (itimegap==0)
roe pread: 10000 ns
roe pskip:  150 ns
roe lskip:  150 ns
roe preamp: gain=low offs=low
roe chipgain: low
roe ffprot: 0
roe oflwprot: 0
roe ems: 0
roe swms: 0
roe pxllns: 7
roe shortint: 0
roe simadc: 0
Nirvanamathar> subwin
subwin: off   (HW-windowing enabled)
HW-windowing is off  with 0 active of 0 set HW-wins (0 act.pixels)
SW-windowing is off  with 0 active of 0 set SW-wins (0 act.pixels)

OK
Nirvanamathar> ls
aa0001.fits
aa0002.fits
aa0003.fits
gain_licntsr_10_0005.fits
gain_licntsr_14_0005.fits
gain_licntsr_18_0005.fits
gain_licntsr_22_0005.fits
gain_licntsr_2_0005.fits
gain_licntsr_6_0005.fits
Nirvanamathar> read
INFO rsim: creating simulated data ...
OK
Nirvanamathar> sh: aumix: command not found
sh: aumix: command not found
simu: READBUF=1
read: time used: 2.689 (sec)
read: terminated ok

Nirvanamathar> ls
aa0001.fits
aa0002.fits
aa0003.fits
gain_licntsr_10_0005.fits
gain_licntsr_14_0005.fits
gain_licntsr_18_0005.fits
gain_licntsr_22_0005.fits
gain_licntsr_2_0005.fits
gain_licntsr_6_0005.fits
Nirvanamathar> save
/home/mathar/DATA/aa0004.fits
sh: aumix: command not found
sh: aumix: command not found
DEBUG save: real time used: 0.0795 (seconds)
save: terminated ok
OK
Nirvanamathar>
```

Figure 10: The command interpreter started with the `Module`→`New Instrument Shell` menu of Figure 6.

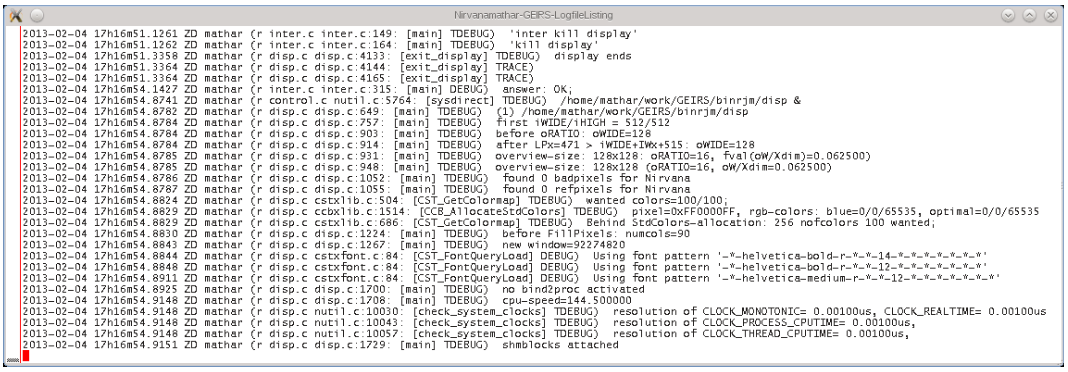
- a debugging level,
- and some more or less cryptic trace of what has been executed at that time.

The arrows `->` and `<-` show what was sent to and what was responded by the ROE.

The monitor of the error logs, Figure 12, shows the messages tagged with log levels `FATAL`, `ERROR` and `WARNING` in the `debug*.log` file.

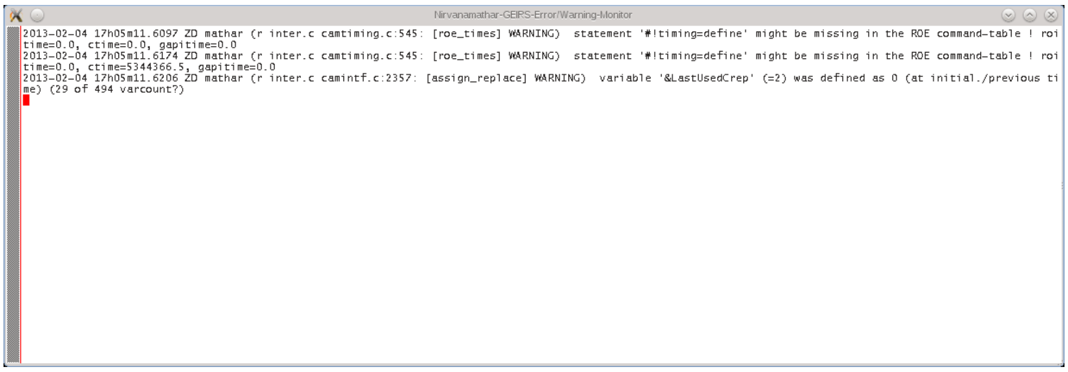
The monitor of the ROE logs, Figure 13, tracks `log/roe*.log`, and shows a time stamp, the user name on the host machine, the camera name, and two kinds of lines:

1. Entry and exit from one of the functions that accumulate (compute) the duration of patterns and loops over patterns,
2. Patterns submitted to the ROE. The `tout` shows the timeout (in seconds) for waiting for an answer.



```
2013-02-04 17h16m51.1261 ZD mathar (r inter.c inter.c:149: [main] TDEBUG)  'inter kill display'
2013-02-04 17h16m51.1262 ZD mathar (r inter.c inter.c:164: [main] TDEBUG)  'kill display'
2013-02-04 17h16m51.3358 ZD mathar (r disp.c disp.c:4133: [exit_display] TDEBUG)  display ends
2013-02-04 17h16m51.3364 ZD mathar (r disp.c disp.c:4144: [exit_display] TRACE)
2013-02-04 17h16m51.3364 ZD mathar (r disp.c disp.c:4165: [exit_display] TRACE)
2013-02-04 17h16m54.1427 ZD mathar (r inter.c inter.c:315: [main] DEBUG)  answer: OK;
2013-02-04 17h16m54.8741 ZD mathar (r control.c nutil.c:5764: [sysdirect] TDEBUG)  /home/mathar/work/GEIRS/binrjm/disp &
2013-02-04 17h16m54.8782 ZD mathar (r disp.c disp.c:649: [main] TDEBUG)  (1) /home/mathar/work/GEIRS/binrjm/disp
2013-02-04 17h16m54.8784 ZD mathar (r disp.c disp.c:757: [main] TDEBUG)  first iWIDE/iHIGH = 512/512
2013-02-04 17h16m54.8784 ZD mathar (r disp.c disp.c:903: [main] TDEBUG)  before oRATIO: oWIDE=128
2013-02-04 17h16m54.8784 ZD mathar (r disp.c disp.c:914: [main] TDEBUG)  after LPx=471 > iWIDE+IWx+515: oWIDE=128
2013-02-04 17h16m54.8785 ZD mathar (r disp.c disp.c:931: [main] TDEBUG)  overview-size: 128x128: oRATIO=16, fval(oW/Xdim)=0.062500)
2013-02-04 17h16m54.8785 ZD mathar (r disp.c disp.c:948: [main] TDEBUG)  overview-size: 128x128 (oRATIO=16, oW/Xdim=0.062500)
2013-02-04 17h16m54.8786 ZD mathar (r disp.c disp.c:1052: [main] TDEBUG)  found 0 badpixels for Nirvana
2013-02-04 17h16m54.8787 ZD mathar (r disp.c disp.c:1055: [main] TDEBUG)  found 0 refpixels for Nirvana
2013-02-04 17h16m54.8824 ZD mathar (r disp.c cstxlib.c:504: [CST_GetColormap] TDEBUG)  wanted colors=100/100;
2013-02-04 17h16m54.8829 ZD mathar (r disp.c ccbxlib.c:1514: [CCB_AllocateStdColors] TDEBUG)  pixel=0xFF0000FF, rgb-colors: blue=0/0/65535, optimal=0/0/65535
2013-02-04 17h16m54.8829 ZD mathar (r disp.c cstxlib.c:686: [CST_GetColormap] TDEBUG)  Behind StdColors-allocation: 256 nofcolors 100 wanted;
2013-02-04 17h16m54.8830 ZD mathar (r disp.c disp.c:1224: [main] TDEBUG)  before FillPixels: numcols=90
2013-02-04 17h16m54.8843 ZD mathar (r disp.c disp.c:1267: [main] TDEBUG)  new window=92274820
2013-02-04 17h16m54.8844 ZD mathar (r disp.c cstxfont.c:84: [CST_FontQueryLoad] DEBUG)  Using font pattern '-*-helvetica-bold-r-*-*-14-*-*-*-*-*-*'
2013-02-04 17h16m54.8848 ZD mathar (r disp.c cstxfont.c:84: [CST_FontQueryLoad] DEBUG)  Using font pattern '-*-helvetica-bold-r-*-*-12-*-*-*-*-*'
2013-02-04 17h16m54.8911 ZD mathar (r disp.c cstxfont.c:84: [CST_FontQueryLoad] DEBUG)  Using font pattern '-*-helvetica-medium-r-*-*-12-*-*-*-*-*-*'
2013-02-04 17h16m54.8925 ZD mathar (r disp.c disp.c:1700: [main] TDEBUG)  no bind2proc activated
2013-02-04 17h16m54.9148 ZD mathar (r disp.c disp.c:1708: [main] TDEBUG)  cpu-speed=144.500000
2013-02-04 17h16m54.9148 ZD mathar (r disp.c nutil.c:10030: [check_system_clocks] TDEBUG)  resolution of CLOCK_MONOTONIC= 0.00100us, CLOCK_REALTIME= 0.00100us
2013-02-04 17h16m54.9148 ZD mathar (r disp.c nutil.c:10043: [check_system_clocks] TDEBUG)  resolution of CLOCK_PROCESS_CPUTIME= 0.00100us,
2013-02-04 17h16m54.9148 ZD mathar (r disp.c nutil.c:10057: [check_system_clocks] TDEBUG)  resolution of CLOCK_THREAD_CPUTIME= 0.00100us,
2013-02-04 17h16m54.9151 ZD mathar (r disp.c disp.c:1729: [main] TDEBUG)  shmblocks attached
```

Figure 11: The logging monitor opened with the `Module`→`DebugLog-Mon` menu of Figure 6. Another logfile is opened at UTC midnight, so one needs to close and reopen this GUI after midnight.



```
2013-02-04 17h05m11.6097 ZD mathar (r inter.c camtiming.c:545: [roe_times] WARNING)  statement '#!timing=define' might be missing in the ROE command-table ! roi
time=0.0, ctime=0.0, gapitime=0.0
2013-02-04 17h05m11.6174 ZD mathar (r inter.c camtiming.c:545: [roe_times] WARNING)  statement '#!timing=define' might be missing in the ROE command-table ! roi
time=0.0, ctime=5344366.5, gapitime=0.0
2013-02-04 17h05m11.6206 ZD mathar (r inter.c camintf.c:2357: [assign_replace] WARNING)  variable '&LastUsedCrep' (=2) was defined as 0 (at initial./previous ti
me) (29 of 494 varcount?)
```

Figure 12: The monitor opened with the `Module`→`ErrorLog-Mon` menu of Figure 6. Another logfile is opened at UTC midnight, so one needs to close and reopen this GUI after midnight.

The monitor of the command logs, Figure 14, tracks `log/cmd*.log`. The `inter` flags that the line was generated by a shell script assembled by the command shell with `sh -c`, and the following `i`, `c` or `s` means the caller was the interactive gui, a command, or the shell, respectively.

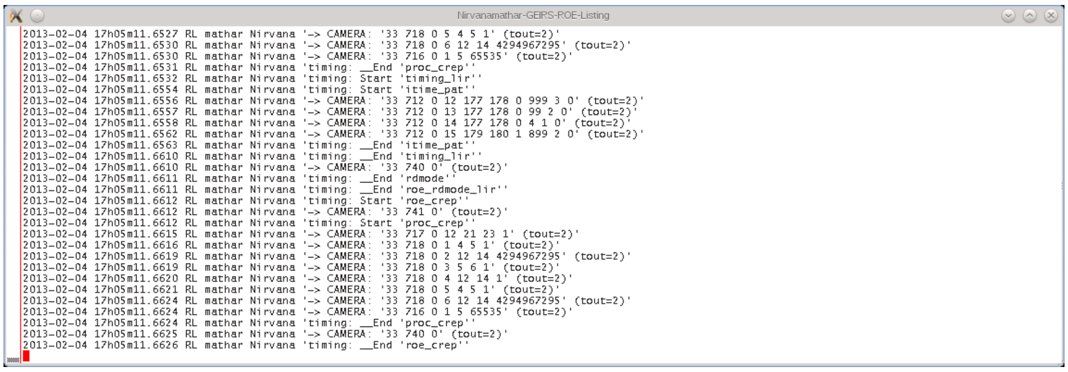
4.3.3 Real-time Display

The display tool, Figure 15 works similar to `ds9` or `fv` tools with some display options and similar statistics. The GEIRS display, however, is completely unaware of world coordinate systems standards.

The main difference against saving the image as a FITS file and then calling these standard displays is that one can address any picture in the current memory buffer rather quickly by its index. It is also easier to navigate through pictures if windowing was used, because GEIRS has no means to glue a set of subwindows. (geirs2Panic has been written to merge these frames after they have been stored as FITS files.)

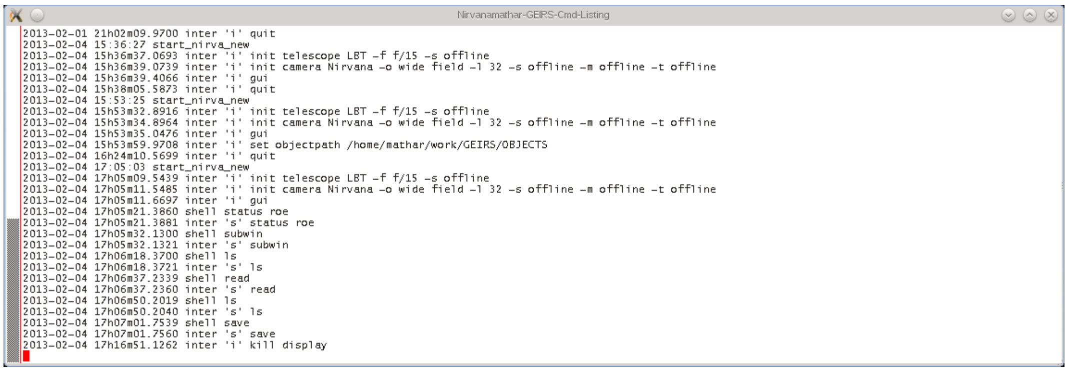
xpa is compiled for example by installing the `heatools` (Section A.6.4). If `xpa` available, users can send a duplicate of each new FITS file that is generated by the `save` command to an online ds9 application by adding two lines like

```
Xpaset=‘type xpaset | awk ’{print $3}’‘
cat $1 | $Xpaset ds9 fits
```



```
2013-02-04 17h05m11.6527 RL mathar Nirvana '-> CAMERA: '33 718 0 5 4 5 1' (tout=2)'
2013-02-04 17h05m11.6530 RL mathar Nirvana '-> CAMERA: '33 718 0 6 12 14 4294967295' (tout=2)'
2013-02-04 17h05m11.6530 RL mathar Nirvana '-> CAMERA: '33 716 0 1 5 65535' (tout=2)'
2013-02-04 17h05m11.6531 RL mathar Nirvana 'timing: __End 'proc_crep''
2013-02-04 17h05m11.6532 RL mathar Nirvana 'timing: Start 'timing_lir''
2013-02-04 17h05m11.6554 RL mathar Nirvana 'timing: Start 'itime_pat''
2013-02-04 17h05m11.6556 RL mathar Nirvana '-> CAMERA: '33 712 0 12 177 178 0 999 3 0' (tout=2)'
2013-02-04 17h05m11.6557 RL mathar Nirvana '-> CAMERA: '33 712 0 13 177 178 0 99 2 0' (tout=2)'
2013-02-04 17h05m11.6558 RL mathar Nirvana '-> CAMERA: '33 712 0 14 177 178 0 4 1 0' (tout=2)'
2013-02-04 17h05m11.6562 RL mathar Nirvana '-> CAMERA: '33 712 0 15 179 180 1 899 2 0' (tout=2)'
2013-02-04 17h05m11.6563 RL mathar Nirvana 'timing: __End 'itime_pat''
2013-02-04 17h05m11.6610 RL mathar Nirvana 'timing: __End 'timing_lir''
2013-02-04 17h05m11.6610 RL mathar Nirvana '-> CAMERA: '33 740 0' (tout=2)'
2013-02-04 17h05m11.6611 RL mathar Nirvana 'timing: __End 'rdmode''
2013-02-04 17h05m11.6611 RL mathar Nirvana 'timing: __End 'roe_rdmode_lir''
2013-02-04 17h05m11.6612 RL mathar Nirvana 'timing: Start 'roe_crep''
2013-02-04 17h05m11.6612 RL mathar Nirvana '-> CAMERA: '33 741 0' (tout=2)'
2013-02-04 17h05m11.6612 RL mathar Nirvana 'timing: Start 'proc_crep''
2013-02-04 17h05m11.6615 RL mathar Nirvana '-> CAMERA: '33 717 0 12 21 23 1' (tout=2)'
2013-02-04 17h05m11.6616 RL mathar Nirvana '-> CAMERA: '33 718 0 1 4 5 1' (tout=2)'
2013-02-04 17h05m11.6619 RL mathar Nirvana '-> CAMERA: '33 718 0 2 12 14 4294967295' (tout=2)'
2013-02-04 17h05m11.6619 RL mathar Nirvana '-> CAMERA: '33 718 0 3 5 6 1' (tout=2)'
2013-02-04 17h05m11.6620 RL mathar Nirvana '-> CAMERA: '33 718 0 4 12 14 1' (tout=2)'
2013-02-04 17h05m11.6621 RL mathar Nirvana '-> CAMERA: '33 718 0 5 4 5 1' (tout=2)'
2013-02-04 17h05m11.6624 RL mathar Nirvana '-> CAMERA: '33 718 0 6 12 14 4294967295' (tout=2)'
2013-02-04 17h05m11.6624 RL mathar Nirvana '-> CAMERA: '33 716 0 1 5 65535' (tout=2)'
2013-02-04 17h05m11.6624 RL mathar Nirvana 'timing: __End 'proc_crep''
2013-02-04 17h05m11.6625 RL mathar Nirvana '-> CAMERA: '33 740 0' (tout=2)'
2013-02-04 17h05m11.6626 RL mathar Nirvana 'timing: __End 'roe_crep''
```

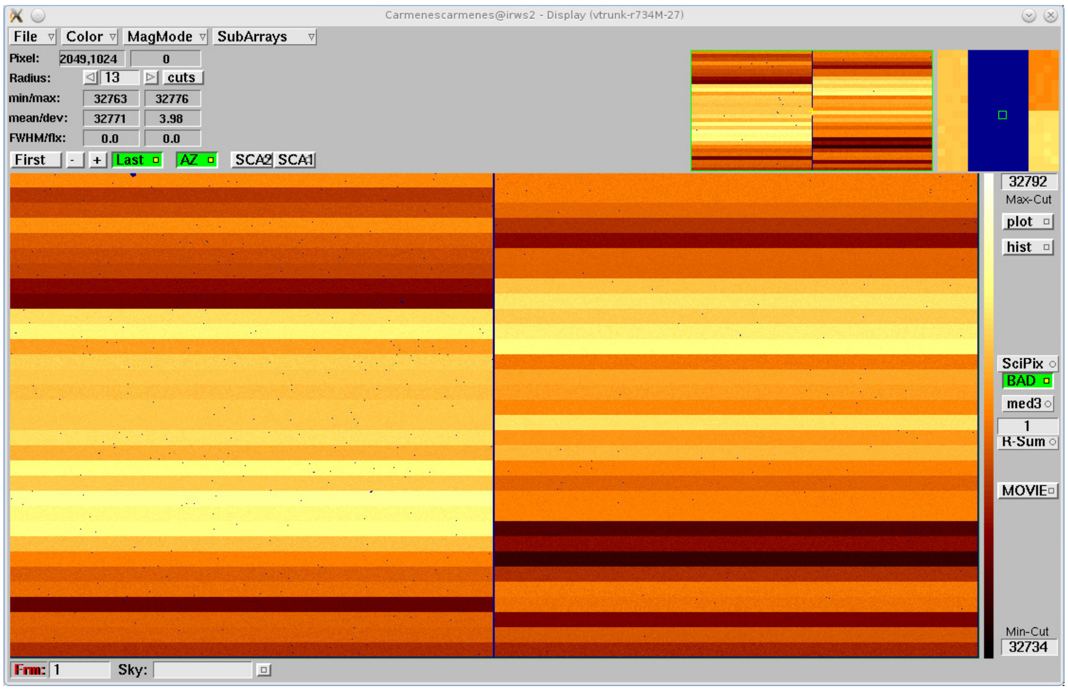
Figure 13: The monitor opened with the `Module`→`RoeLog-Mon` menu of Figure 6. Another logfile is opened at UTC midnight, so one needs to close and reopen this GUI after midnight.



```
2013-02-01 21h02m09.9700 inter 'i' quit
2013-02-04 15:36:27 start_nirva_new
2013-02-04 15h36m37.0693 inter 'i' init telescope LBT -f f/15 -s offline
2013-02-04 15h36m39.0739 inter 'i' init camera Nirvana -o wide field -l 32 -s offline -m offline -t offline
2013-02-04 15h36m39.4066 inter 'i' gui
2013-02-04 15h38m05.5873 inter 'i' quit
2013-02-04 15:53:25 start_nirva_new
2013-02-04 15h53m32.8916 inter 'i' init telescope LBT -f f/15 -s offline
2013-02-04 15h53m34.8964 inter 'i' init camera Nirvana -o wide field -l 32 -s offline -m offline -t offline
2013-02-04 15h53m35.0476 inter 'i' gui
2013-02-04 15h53m59.9708 inter 'i' set objectpath /home/mathar/work/GEIRS/OBJECTS
2013-02-04 16h24m10.5699 inter 'i' quit
2013-02-04 17:05:03 start_nirva_new
2013-02-04 17h05m09.5439 inter 'i' init telescope LBT -f f/15 -s offline
2013-02-04 17h05m11.5485 inter 'i' init camera Nirvana -o wide field -l 32 -s offline -m offline -t offline
2013-02-04 17h05m11.6697 inter 'i' gui
2013-02-04 17h05m21.3860 shell status roe
2013-02-04 17h05m21.3881 inter 's' status roe
2013-02-04 17h05m32.1300 shell subwin
2013-02-04 17h05m32.1321 inter 's' subwin
2013-02-04 17h06m18.3700 shell ls
2013-02-04 17h06m18.3721 inter 's' ls
2013-02-04 17h06m37.2339 shell read
2013-02-04 17h06m37.2360 inter 's' read
2013-02-04 17h06m50.2019 shell ls
2013-02-04 17h06m50.2040 inter 's' ls
2013-02-04 17h07m01.7539 shell save
2013-02-04 17h07m01.7560 inter 's' save
2013-02-04 17h16m51.1262 inter 'i' kill display
```

Figure 14: The monitor opened with the `Module`→`CmdLog-Mon` menu of Figure 6. Another logfile is opened at UTC midnight, so one needs to close and reopen this GUI after midnight.

to the `QueueFiles` shell script (Sec. 3.3). As an alternative to using the `type` command one may use the full path of `xpaset` or make sure by symbolic links that the `path` contains the executable. Note that `ds9` sometimes needs to read `ds9-64` depending on how this was compiled. With that setup, opening the GUI in Figure 15 may be superfluous.


Carmenescarmenes@irws2 - Display (vtrunk-r734M-27)

Pixel: 2049,1024 0
Radius: 13
min/max: 32763 32776
mean/dev: 32771 3.98
FWHM/flx: 0.0 0.0
32792 Max-Cut
1
Min-Cut 32734
Frm: 1
Sky:

Figure 15: Current Exposure Display. In this example, an image/frame taken from a readout electronics with open (disconnected) inputs is shown. A single-frame-read mode was chosen to enhance the visibility of the stripes of the two detector's channels.

The display tool of Figure 15 shows one frame of the current set of data.

Contrast and offset of the brightness on the screen may be changed by clicking the right mouse button. The contrast of the new display depends on how far up/down the cursor is in the image when clicked, and the offset depends on how far to the left or right it is. This modifies the slope and interception of the function which maps the pixel values, ADU's, to the brightness. An indication which color/appearance is equivalent to which pixel value is given by the long color bar right from the main image, which stretches from the `Min-Cut` field up to the `Max-Cut` field. The display uses a linear map for the translation of ADU's to brightness by default (i.e., after GEIRS has been started). A γ-correction with a power law scaling is available by setting the `DISP_GAMMA` value of the shared memory database to some different value in the range $0 \le \gamma \le 100$ with the `put` command (Section 5.3), for example

```
put DISP_GAMMA 1.4
```

The default after GEIRS startup is $\gamma = 1$.

The magnified subwindow in the upper right corner is selected by clicking with the left mouse button at some place in the main window, then moving around with the four arrow (cursor) keys. So a pre-selection of the region seen in the magnifier window happens with a left mouse click in the main window, and a finer selection may follow by either left mouse clicks in the magnifier window or with the arrow keys.

Zooming the main window is done by pressing the minus key (or the minus-key in the auxiliary keypad or one of the the page-up keys in the auxiliary keypad, or CTRL left mouse button to the same effect) or the plus key (or the plus-key in the auxiliary keypad or one of the the page-down keys in the auxiliary keypad, or the equal key, or CTRL plus right mous button to the same effect). The minus key zooms out and the plus key zooms in. The current region covered by the main display is indicated by a green square in the auxiliary overview window (which displays a yellow cross to indicate the current cursor position). The auto-zoom button turns from green to gray while only a portion of the full detector area is in the main window.

Moving (translating) the region in the main window may be done by click-holding the left mouse button in the overview window and moving the cursor. Alternatively, CTRL or shift combined with middle-mouse clicks in the main window moves the region in a direction and with a stride depending on where the cursor is relative to the center of the main window. The green rectangle in the overview window indicates the current region visible in the main window.

Clicking on the `AZ` (autozoom) button is the quickest way to re-center and re-scale the main window to the full detector region.

Some on-line data processing techniques are available. These techniques affect only the displayed data, not the raw data saved to disk. In addition there are various helpful options to move the telescope virtually to certain positions.

- **File Menu** selects the basic display size:
  - **256** changes display window to 256×256 screen pixels. The full image is displayed, binned 8×8. Note that in general you will not see your objects in highly binned mode as they most often will happen to fall between the displayed pixels!
  - **512** changes display window to 512×512 screen pixels.
  - **1024** changes display window to 1024×1024 screen pixels.

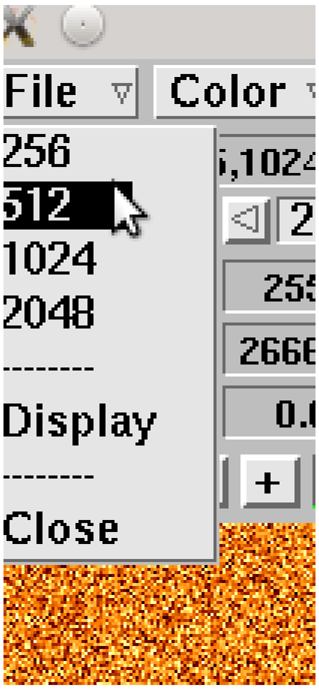


Figure 16: File dropdown Menu

- **2048** changes display window to 2048 × 2048 screen pixels. The display will not fit onto your monitor screen in this case!
- **Display** Opens a second display window with a pixel size of 1024 × 1024 in an independent screen.
- **Close** Closes the window. It can be restarted by selecting `display` under the module menu of the camera control window or by the `display` command (Section 5.3).

• **Color** Menu selects the colour look-up table for displaying images.

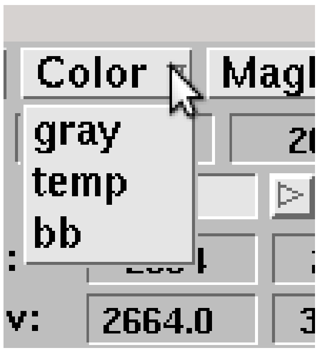


Figure 17: Color dropdown Menu

- **gray** is a black-and-white colour look-up table.
- **temp** is the standard "temperature" colour table.
- **bb** is the standard blackbody colour table.

• **MagMode** Menu switches between the zoom window and a measurement of the image seeing.

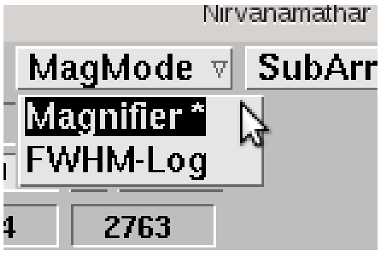


Figure 18: Magnifier dropdown Menu

- **Magnifier** Zoom window, this is the default mode.
- **FWHM-Log** Measures the FWHM of the indicated object each time a new image is displayed, and plots a running history of the values. This is useful for rough focusing. To get reasonably accurate measurements of the FWHM, the aperture of the box used (set with radius, see below) must be large enough to include a couple of rows of sky pixels around the object.

- **SubArrays** Relocates the frames read as subwindows specified by the `subwin` command into the full detector geometry on a black background. The two available choices are (i) to show the windows that will actually be stored in the FITS files (Figure 19) or (ii) to show the information sent from the ROE to the workstation (Figure 20) prior to the additional clipping. Many examples of this look are shown in the "Subarrays" section of [12]. The

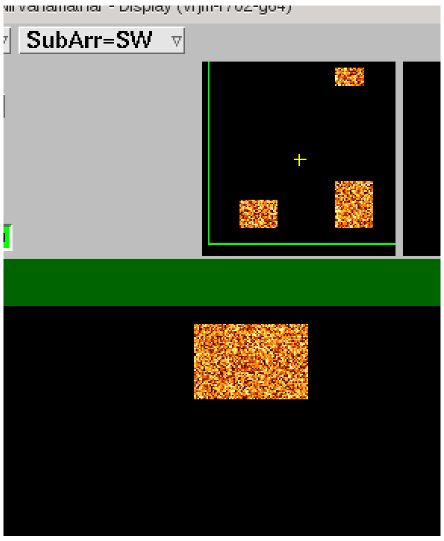


Figure 19: Subarray menu of Figure 15 with the "software" windows.

difference between these sets of pixels in the two displays is detailed elsewhere [5].

There is some potential impact on setting up exposures: The cycle time of the exposures is "spent" by the read-out and ADC conversion to generate the wider set of data shown in Figure 20, which is then cut into the smaller pieces by GEIRS on the workstation to the customized slices of Figure 19. Once knowing the geometries of the associated larger "hardware" windows, one could reconfigure the geometry of the "software" windows to span the same, entire area of the "hardware" windows, basically gathering the wider field without any noticeable change in the integration time!

- **Pixel** When the cursor is in the image display window, the pixel position (x and y seperated by a comma) and counts at that pixel are displayed here.

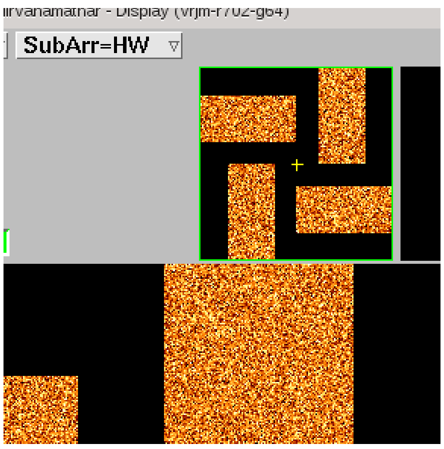
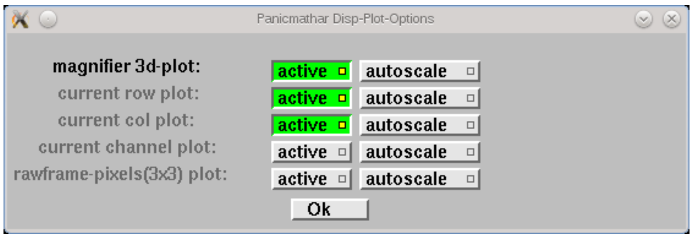


Figure 20: Subarray menu of Figure 15 with the "hardware" windows.

- **Radius** Sets the radius of the small cursor box in the image display. See the above note on FWHM-log about measuring the seeing. Pressing the `cuts` button lets the result become the new choice for the cuts of the entire display.
- **min/max** Show the minimum and maximum values of the pixels within the cursor box.
- **mean/dev** Shows the mean and standard deviation of the pixels within the cursor box.
- **FWHM/flx** Shows the FWHM and total flux (in counts) of an object selected with the cursor box.
- **First - + Last** Steps through a series of images in the current memory: displays the first image, moves one backward, one forward or skips to the last. Unless you need to review a set of images to determine, for example, whether the seeing was good enough to bother saving the data, just leave this on last. If the `Img:` in the lower left corner is not set to `Img:` but to Frm:, the GUI switches to frames instead of images for display and indexing.
- **AZ** Clicking on `AZ` rescales the main image to fill the frame, so the full detector area is visible.
- **plot** Plots cuts and surfaces through the current image on the display. An auxiliary GUI as in Figure 21 appears. This button is disabled if `gnuplot` was not found at compile time (Section 2.1.5).


Panicmathar Disp-Plot-Options

magnifier 3d-plot:	active ✓	autoscale
current row plot:	active ✓	autoscale
current col plot:	active ✓	autoscale
current channel plot:	active	autoscale
rawframe-pixels(3x3) plot:	active	autoscale

Ok

Figure 21: Auxiliary options after pressing the `plot` button in the main display GUI, Fig. 15.

If all five options are activated, five gnuplot graphs similar to Figure 22 appear. The channel plot is initially 128 thousand pixels wide on the horizontal axis, which is the number of pixels in one channel for the 2048 × 2048 array distributed over the 32 channels assigned to each detector chip by the MPIA readout electronics. (Without zooming in, the line density in the `Channel` plot is so large that the entire graph assumes the red line color, because the y-axis scale is taken from the current cuts of the main display. This may be changed with the `autoscale` options in Figure 21.) The channel is selected by the current position of the cursor.

- **hist** Pushing this button creates a histogram of pixel statistics for the currently selected frame or image. This button is disabled if `gnuplot` was not found at compile time (Section 2.1.5). First a temporary FITS file is created on disk. Then an auxiliary GUI appears which allows to select primarily the coordinates of a rectangle in pixel units over the detectors and cuts in ADU units. If the `continue` button in this auxiliary GUI is pressed, the histogram is shown by calling the `fitsImg2Asc` program in the `extern` subdirectory.

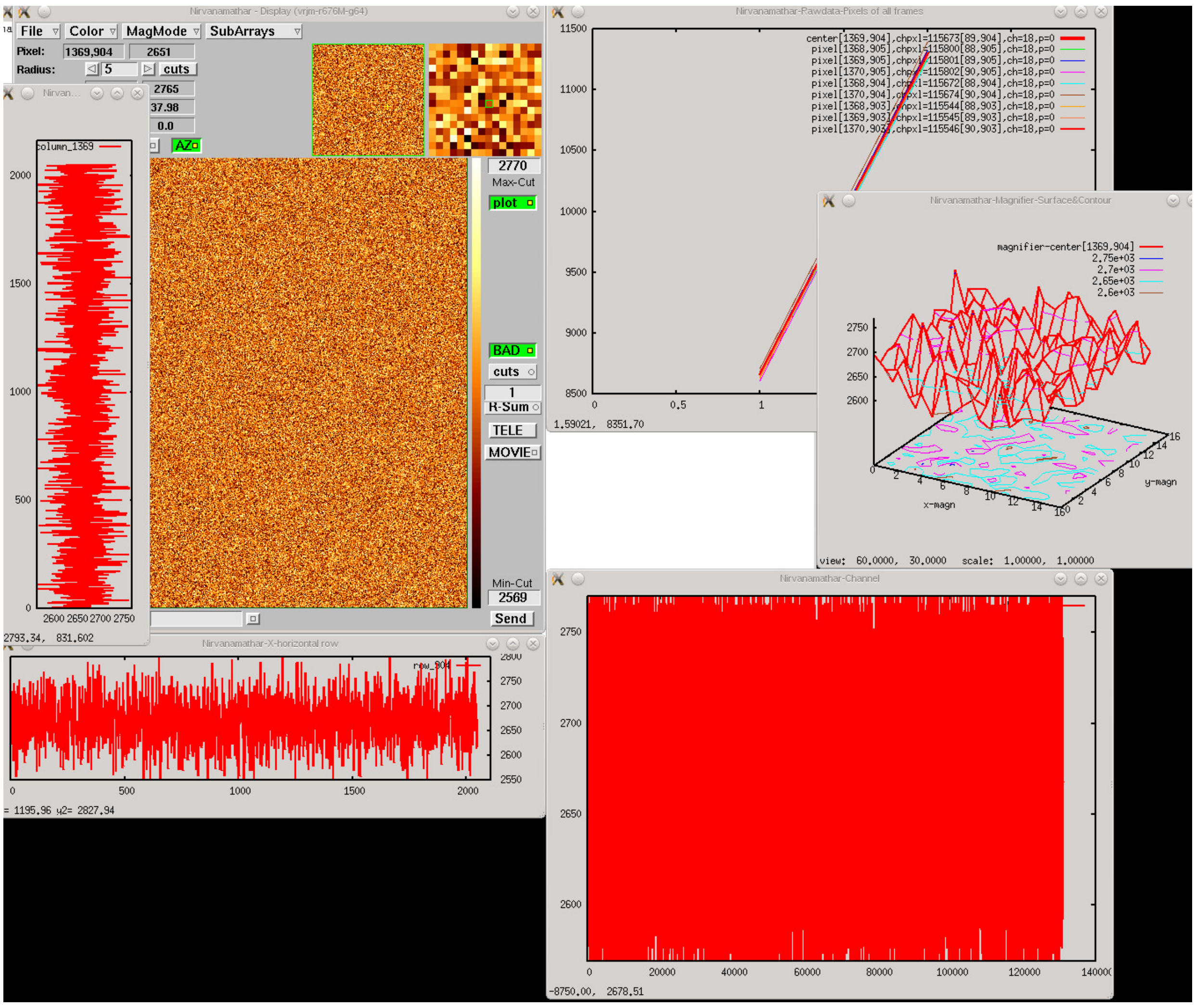

Nirvanamathar - Display (vrjm-r676M-g64)
File
Color
MagMode
SubArrays
Pixel:
1369,904
2651
Radius:
5
cuts
2765
37.98
0.0
AZ
2770
Max-Cut
plot
BAD
cuts
1
R-Sum
TELE
MOVIE
Min-Cut
2569
Send
column_1369
2793.34, 831.602
Nirvanamathar-X-horizontal row
row_904
= 1195.96 y2= 2827.94
Nirvanamathar-Rawdata-Pixels of all frames
center[1369,904],chpxl=115673[89,904],ch=18,p=0
pixel[1368,905],chpxl=115800[88,905],ch=18,p=0
pixel[1369,905],chpxl=115801[89,905],ch=18,p=0
pixel[1370,905],chpxl=115802[90,905],ch=18,p=0
pixel[1368,904],chpxl=115672[88,904],ch=18,p=0
pixel[1370,904],chpxl=115674[90,904],ch=18,p=0
pixel[1368,903],chpxl=115544[88,903],ch=18,p=0
pixel[1369,903],chpxl=115545[89,903],ch=18,p=0
pixel[1370,903],chpxl=115546[90,903],ch=18,p=0
1.59021, 8351.70
Nirvanamathar-Magnifier-Surface&Contour
magnifier-center[1369,904]
2.75e+03
2.7e+03
2.65e+03
2.6e+03
x-magn
y-magn
view: 60.0000, 30.0000 scale: 1.00000, 1.00000
Nirvanamathar-Channel
-8750.00, 2678.51

Figure 22: Plots derived from the Display GUI after `OK` in Figure 21.

- **RefPix** There is a button above the `BAD` button only visible for instruments with Hawaii2-RG chip, and therefore not seen in Figure 15. This offers three states: `RefPix`, `AllPix` and `SciPix`. The area of 2048 × 2048 pixels of each chip is dissected into the frame 4 reference pixels wide along each edge, and the interior 2040 × 2040 data pixels that are the relevant data from the astronomer's point of view. The button offers to put a mask over either the reference or the scientifically useful pixels or to show the union of both sets of pixels at the same time.

- **BAD** Toggles between displaying the bad pixels (in red) or not. Note that the bad pixels are ignored when determining display cuts only if the bad pixels are turned on. The bad-pixel mask is a text file stored in `$CAMINFO/badpixels.`*instru*, where `CAMINFO` typically equals `$CAMHOME/INFO`, and the *instru* is `nirvana`, or `carmenes` or `panic` or `luci2`. The file contains a list of x and y specifications in the IRAF convention. Each line starts either with the x and y coordinate of a bad pixel or with the start-x, end-x, start-y and end-y coordinates of a rectangle of bad pixels. The coordinate pair or quadruple is separated by white space. Each coordinate is 1-based (as in FITS) and ranges from 1 up to the detector size (2048 for instruments with a single $2k \times 2k$ chip, 4096 for PANIC). Coordinates that fall outside the two dimensions of the detector are clipped and effectively ignored. Lines in the file that start with less than two numbers are skipped.

(The program `fitsImg2Asc` in geirs2Panic offers an option `-b` to convert a FITS image into that ASCII format based on two-sided clipping of the histogram.)

- **Cuts** Display stretch control, Figure 23. This button brings up a menu with various options for determining the minimum and maximum display levels. The options include:

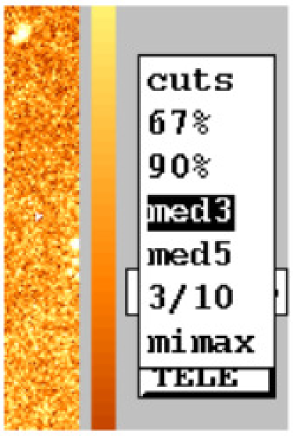


Figure 23: Cuts dropdown Menu

  - **Cuts** Allows you to enter your own minimum and maximum display levels in the "Min-Cut" and "MaxCut" windows.
  - **67%** Sets the display range to cover 67% of the full dynamic range of the data.
  - **90%** Sets the display range to cover 90% of the full dynamic range of the data.
  - **med3** Sets the display from (mean - 3σ) to (mean + 3σ).
  - **med5** Sets the display from (mean - 5σ) to (mean + 5σ).
  - **3/10** Sets the display from (mean - 3σ) to (mean + 10σ).
  - **minmax** Sets the display range to cover the full dynamic range of the data.

- **Min-Cut** and **Max-Cut**: These windows show the current minimum and maximum levels used for the display. They will automatically update each time a new image is displayed except if using the "Cuts" option.

- **Single/R-Sum/R-Ave/TotSum/TotAve**, Figure 24. `Single` will display each individual read as it comes off the camera. `R-sum` Adds as many images as implied by the integer parameter of the auxiliary entry with a boxcar selection of the range. If the integer parameter equals 1, this is effectively the same as `Single`. (This type of sliding average is used in financial markets to smooth data without loosing trends. . .). `TotSum` will display the sum of all images

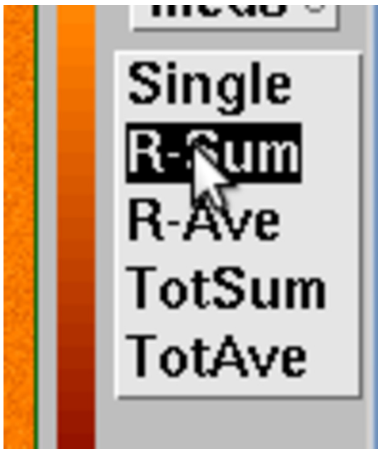


Figure 24: Frame integration dropdown Menu

taken in the current series. `TotAve` displays the average of all images taken in the current series. (The sky frame, if one is active, is subtracted off these summation procedures and the cuts applied thereafter.)

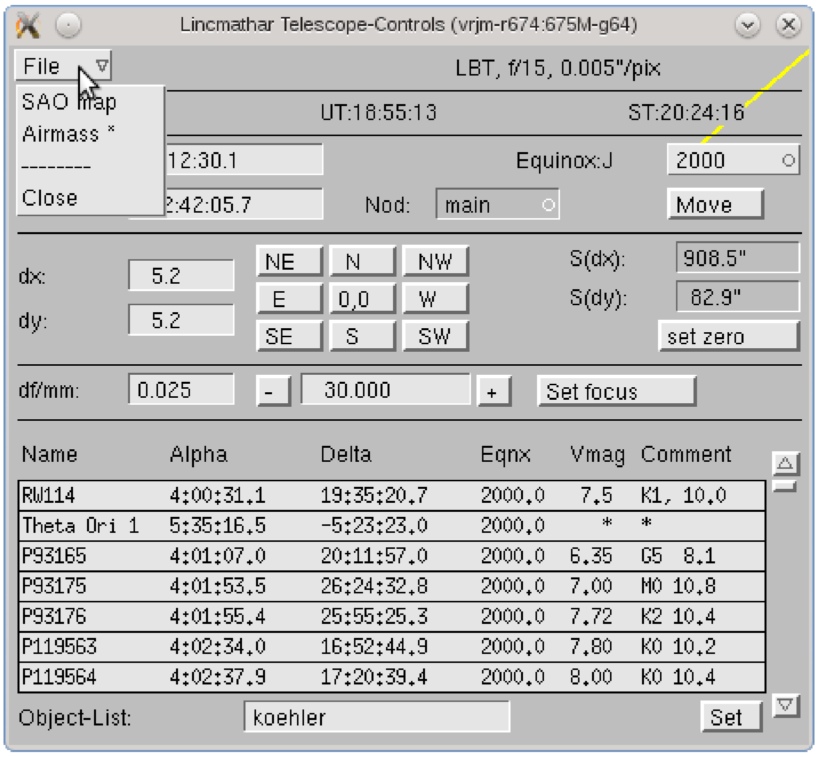
All these actions are virtual for all telescopes outside CAHA and basically irrelevant to NIRVANA operations.

- **Movie** Plays a movie of the series of exposures currently in memory.
- **Img** shows which image in a series of repeated exposures is currently being displayed. One may select in the pop-up menu a more precise meaning: whether the display shows the *frames* enumerated as received by the ROE, or whether the *images* are shown, which in double- or multi-correlated modes are differential versions of multiple frames. There is also a *Dynamic* option which lets the display show the frames at the start of an exposure but switch to the images after a time defined by the time difference between the arrival of the frames.
- **Sky** The `sky` button (small square) tells the computer to subtract a sky frame from the images before displaying, and is on when the square appears green. The file used for the sky frame is specified by entering a name (with the `.fits` suffix) in the window to the left of the button. The menu that pops up if one clicks with the left mouse button into the field proposes in addition two images that are not (yet) on disk but a previous frame in memory. (One of the options is to mark the current image as the reference for subtractions in the future, the other is to subtract the image immediately preceeding the current one.) This sky subtraction also effects the pixel values displayed in the upper part of the window. Be aware of this when checking count levels / saturation of a displayed image!

4.3.4 Telescope control window

Section 4.3.4 has no relevance to instruments besides PANIC.

Virtual control of the telescope, such as moving to an absolute position or offsetting from the current position, is done on the telescope control panel. The basic information from the telescope, such as airmass, UT, and current telescope position is also displayed here. This GUI panel should start automatically when the GUI is first initialized. If not, you can call it up from the camera control window (Fig. 6) in the menu `Modules`→`Telescope`.



LBT, f/15, 0.005"/pix

UT:18:55:13 ST:20:24:16

12:30.1 Equinox:J 2000

2:42:05.7 Nod: main

dx: 5.2

dy: 5.2

S(dx): 908.5"

S(dy): 82.9"

df/mm: 0.025 30.000

Name	Alpha	Delta	Eqnx	Vmag	Comment
RW114	4:00:31.1	19:35:20.7	2000.0	7.5	K1, 10.0
Theta Ori 1	5:35:16.5	-5:23:23.0	2000.0	*	*
P93165	4:01:07.0	20:11:57.0	2000.0	6.35	G5 8.1
P93175	4:01:53.5	26:24:32.8	2000.0	7.00	M0 10.8
P93176	4:01:55.4	25:55:25.3	2000.0	7.72	K2 10.4
P119563	4:02:34.0	16:52:44.9	2000.0	7.80	K0 10.2
P119564	4:02:37.9	17:20:39.4	2000.0	8.00	K0 10.4

Object-List: koehler

Figure 25: Telescope control window

GEIRS keeps some basic set of telescope parameters for the displays and for inclusion in FITS header keywords. This set of values is not necessarily up-to-date, because GEIRS reads the parameters from the EPICS interface only if it *itself* has forwarded one of the telescope commands and *if* that action terminated successfully. GEIRS does not poll telescope parameters, which means any change of pointing coordinates or focus offset and so on by any commands that bypass GEIRS will *not* be reflected correctly in GEIRS GUI's or FITS files up to the next `telescope` command.

File Menu:

- **Airmass**: Graphical display of the current airmass and plot of the airmass history for the currently set object, Section 4.3.5.
- **Close**: Closes the telescope control panel of Figure 25. This window can be restarted from the modules menu on the camera control panel, Figure 6, or by the `telegui` command (Section 5.3).

Moving to an absolute position An absolute position can be entered directly in the RA and Dec windows. After setting the equinox, the position can be sent to the telescope by clicking on the move button. The RA and Dec windows also display the current telescope position after each offset.

Relative offsets Offsets in arcseconds can be supplied in the dx and dy windows. Clicking on one of the directional buttons in the compass panel will then offset the telescope by the requested amount. The `set zero` button zeroes the cumulative offsets (S(dx) and S(dy)), and the `0,0` button in the centre of the compass returns the telescope to this defined zero position.

Focus The number after the `df/mm` defines a step size (in mm) for focus changes. Pressing the `+` or `-` buttons changes the focus by one step size unit with the selected sign. The `Set focus` button changes the absolute focus to the value between the `-` and `+` buttons (again in units of mm).

Object Files An object file can be given in the Object-List window (the `.object` extension is not needed, although the file must have it). The search path for this file—usually ending `GEIRS/OBJECTS`—may be set in the `OPTIONS`→`ObjectPath...` menu of Figure 6. Objects can be selected with a single click, and set with the set button. Setting an object sends the object's coordinates to the RA and Dec windows. These can then be sent to the telescope computer by clicking on move as described above. A useful feature is that when an object is set, the airmass panel will display the object's current airmass in graphical form, though there is no obligation to actually move to the object. See also Section 4.6 for a description of the format of such an object catalogue.

4.3.5 Air Mass Window

Section 4.3.5 is only relevant to PANIC, not to any other instrument. The airmass window, Figure 26, graphically displays the airmass of the currently selected object (red dot), as well as a tracing of the airmass over several hours of time (blue line). The number of hours depends on the width of the window. This feature is particularly useful when used in conjunction with object files. This feature is only useful when used in conjunction with object files or in simulation, because GEIRS has no information on the actual telescope pointing for this instrument. Objects selected and set from an object file will show their current airmass in the airmass window. The airmass plot will automatically reset to the current telescope position whenever the GUI queries the telescope computer for the current position (for example, when a read command is finished). The airmass window can be turned off by reselecting the `Airmass` option in the file menu of the telescope control panel, Figure 25. Using the `quit` option in the xwindows menu will also close the telescope control panel!

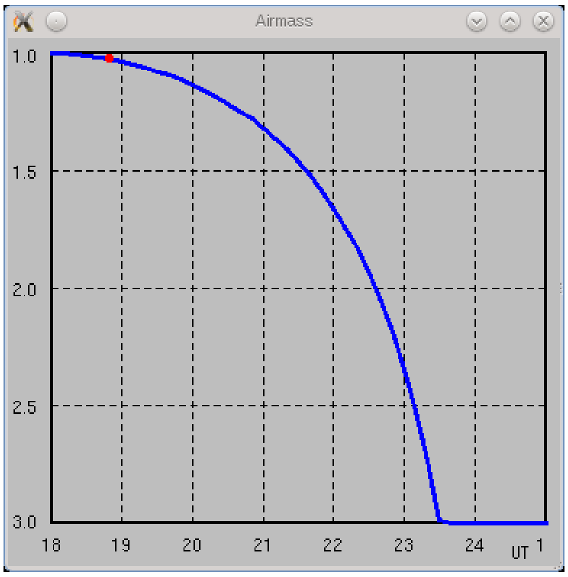
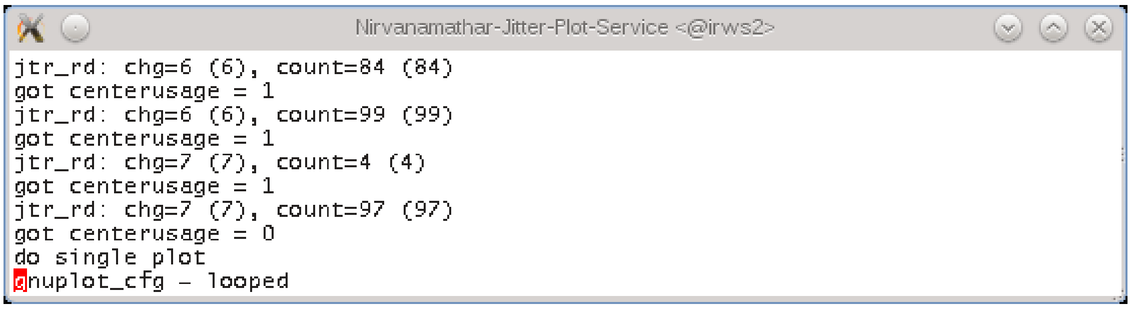


Figure 26: Airmass over time window

4.3.6 Time Jitter Windows

If the software had been compiled with JITTER_TEST defined at two places, and if the data are read via the PLX device —that is, *not* in simulation mode—, the times of arrival of data packes of a `read` are logged, and the differences between these times may be displayed by opening the windows in Figure 27 and 28 by the `JitterPlot` menu of Figure 6.



```
jtr_rd: chg=6 (6), count=84 (84)
got centerusage = 1
jtr_rd: chg=6 (6), count=99 (99)
got centerusage = 1
jtr_rd: chg=7 (7), count=4 (4)
got centerusage = 1
jtr_rd: chg=7 (7), count=97 (97)
got centerusage = 0
do single plot
gnuplot_cfg - looped
```

Figure 27: Jitter Statistics Summary

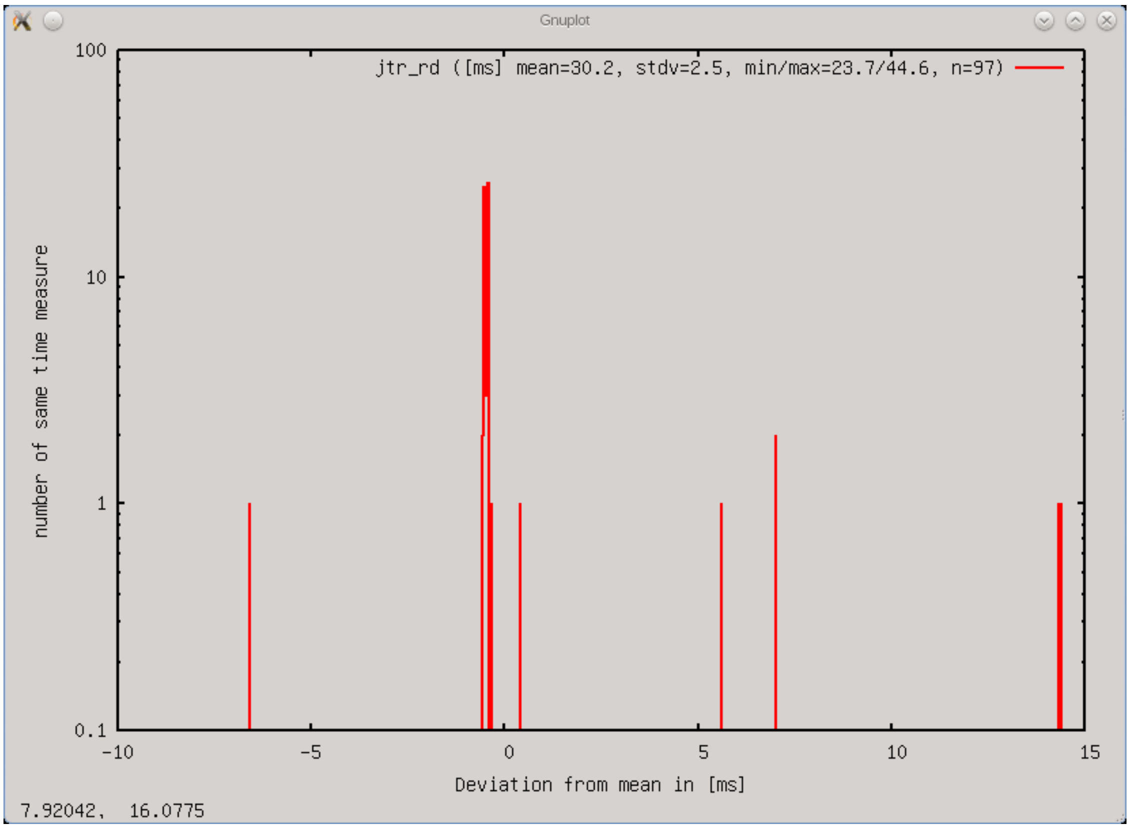


Figure 28: Jitter Statistics Gnuplot Window

The spread of these differences is a rough view on the host computer's system load and responsiveness, and not useful information to astronomers. To gather good statistics in the usual sense, the number of repetitions (in Figure 6 for example or set by the command interpreter) of the `read` needs to be at least some tens.

An overview of the jitter data is kept in `tmp/jitter*.log`.

4.4 Taking data

The windows introduced thus far are the environment in which one takes data manually (including the use of GEIRS macros, see Section 5). This is useful for tests or special calibrations.

4.4.1 Setting up the camera for an exposure

Before you start, make sure you have selected the proper paths for your data etc., see Figure 6 at upper right. You should also set the root name of the files to be stored on disk, which is also done in the camera control window. The instrument is completely setup in the camera control window. Here you select the read-out mode and the exposure times, to name the most important.

4.4.2 Taking exposures

An exposure is taken by pressing the `Read` button (below centre in the camera control window). Although this exposes the image, it is only read into the memory of the instrument computer. There you can use it to take a look at it on the real-time display, measure background level, seeing etc. there. If you decide to keep the image, you also have to decide on the mode on how to save the data (e.g. as a FITS cube, individual images, stacked images) by opening the Save-Options window (Figure 9) with a click of the right mouse button onto the `Save-Options` button of Figure 6. Once set you save the data by pressing the `Save` button. Due to the double buffering, an image may be saved while the next one is already been taken.

4.4.3 Image inspection with the real-time display

The features of the real-time display are described in detail in Section 4.3.3. Please note that you do not manipulate the raw data on disk with these operations.

4.5 Saving data

The data are stored on one of the disks of the instrument computer under the path you have specified under `SavePath` in the Options Menu of the camera control window, Fig. 6. The initial default is `$HOME/DATA` set at start-up time in Section 4.1. The files are stored as FITS files and are not write protected (!).

4.6 Object catalogues

Section 4.6 has only some marginal importance for PANIC, not for any other instrument. An observer's private object list in the following format is supported for use in Figure 25:

```
Object name | Alpha | Delta | Equinox | pm.A | pm.D | mag | Comment
```

Empty lines and portions of lines starting with the semicolon (`;`)—comments—are skipped by the parser.

Example:

```
HD 225023| 0:00:11.8| 35:32:14.0|1950|0.0000|-0.004|6.96|J=7.97
G158-27| 0:04:12.0|-7:47:54.0|1950|-0.056|-1.85|7.43|J=9.31
HD 1160| 0:13:23.1| 3:58:24.0|1950|0.006|-0.013|7.04|J=7.06
HD 3029| 0:31:02.3| 20:09:30.0|1950|-0.0001|0.011|7.09|J=7.25
Gl 105.5| 2:38:07.6| 0:58:57.0|1950|*|*|*|*
HD 18881| 3:00:20.5| 38:12:53.0|1950|0.0001|-0.030|7.14|J=7.12
```

The vertical bar | is used as a separator between fields. If you don't want to put in numbers in some fields, you still have to use a `*` character as a place holder. The comment field following the final separator may be empty.

- The required fields are: Name, Alpha, Delta, Equinox. Leading `J`'s or `B`'s in the equinox field are ignored. If the remaining equinox is not a number, a default of 2000 will be assumed.
- The optional fields are: pm.A and pm.D for the two proper motions in alpha and delta, mag (magnitude), Comment
- The two proper motions pm.A and pm.D are in units of arcsec/century.
- All object list files must have the extension `.object`

If the 2MASS catalog is available in the local file system, the program TwoMassCnvrt with option `-G` can be used to convert a set of targets to this format.

5 COMMAND INTERFACE

5.1 Double buffering

It takes a some amount of time to transfer the data from the camera and save it to the hard-drive on the workstation. To reclaim some of this otherwise lost time, GEIRS has been configured with two image buffers. Thus, a new image can be read out while the previous image is being written to disk. To implement this feature, the macros should be written as in the example above, with a sync tele after the telescope offset and save commands. The GUI will then only wait until the telescope move is completed before starting the next read (the save command may still be in progress).

5.2 Parser

Commands and their arguments are usually submitted one per line, separated by line feeds. If two or more commands are to be send at once, they need to be separated by a semicolon. This makes for example sense for the commands that are almost always followed by the `sync`, for example:

```
save -M ; sync
```

Note that this format generates only a single answer from the interface, not separate answers from the individual commands in the list.

There is one command, `save`, which uses commas to bundle groups of options.

Note that command options cannot be sequeezed into short forms and cannot be swapped with non-optional arguments nor be clumpped without spaces, as some Unices allow in their shells or some higher programming languages support with some getopt(3) libraries. Example:

```
save -zC # wrong syntax !
save -z -C  # valid syntax
```

As a guideline, trailing arguments or options in commands are silently ignored.

5.3 Command List

In this section a complete list of commands is given. The order is lexicographically, not by functionality. These commands and syntax can be used in macros or typed directly into the command window or submitted with the interfaces of Section 3.1. Use with caution some commands are better left out of macros! For example, `quit` will exit a macro at the point it occurs, no further instructions in the macro will be executed. Also, if interactive is on, and `ls`, `dir`, or `history` are used in a macro, the macro could stop executing and wait for a carriage return.

The subsequent pages are a PDF reproduction of the "help" page generated by texinfo in various formats. The intend is to demonstrate to reviewers that this information is indeed available, not to provide a reference that is anyway accessible with the online software. [For this reason, four pages of the PDF document have been packed on a single page of the manual; this also helps to realize that they carry their own internal pagination.]

The options to read this informations are:

1. the `File`→`Help` button in the controls menu, Figure 6, if the *full* path name of a browser has been set in environment variable `CAMBROWSER` in the startup file `scripts/GENERIC`. This is the same as calling

   ```
   setenv CAMBIN=${CAMHOME}/<branch>/share
   firefox ${CAMBIN}/camera.html
   ```

   offline.

2. the `info(1)` command

   ```
   info -f $CAMHOME/<branch>/share/info/camera.info
   ```

   opening the screen similar to Figure 29. This may be simplified as described in Section 2.6.7.

3. as a PDF document

   ```
   cd $CAMHOME/<branch>
   texi2dvi --clean --pdf --expand camera.texi
   evince camera.pdf
   ```

4. the `help` command entered in the command shell.

This is a generic account of the command interface, and again many of these do not apply to CARMENES, in particular the commands that interface with the telescope or motor and other controllers. The commands are either in the category `type:USER` or `type:ENG` or `type:SUPER`; the commands in the latter two categories are rejected unless one is using the instrument under one of the engineering observer ID's or the observer ID `master`. (The observer ID is configured in the top field in the GUI of Figure 4.)

GEIRS Command Interface

Generic Infrared Detector Software
Max-Planck Institute of Astronomy, Heidelberg 8 December 2015

Richard J. Mathar mathar@mpia.de, **Clemens Storz**

Table of Contents

Overview

Interface to the command server of GEIRS, the Generic Infrared Detector Software of MPIA.

1 abort

type: USER
syntax: `abort [-r [-k [#]]] [-m] [-s] [-t] [-a] [-b]`

Aborts the execution of `read` and/or macros.

- `-r`: abort `read` only. See Chapter 51 [read], page 26.
- `-m`: abort `macro` only. See Chapter 38 [macro], page 20.
- `-s`: shorten the initial wait time of the `sync` command and abort the `saad` command. Note that the meaning is *not* that the `sync` waiting state is prematurely left. It only means that the optional additional time delay that is an argument of the `sync` command is cut to zero and that the `sync` starts to wait on the termination of its processes without any artificial further delays. In particular this means that you *cannot* prematurely abort a `read` by an `abort` if a the `sync` has already been send to the interpreter. See Chapter 67 [sync], page 39.
- `-t`: abort `test` only. See Chapter 75 [test], page 45.
- `-a`: abort all processes above here
- -k [#]: kill the read after waiting for # seconds (default is 2s). This tries first a “smooth” kill via a catchable signal, then enforces the kill.

The default, if no options are used, is to abort everything except `save`.

The file `geirsLstAbort` in the directory `$CAMTMP` (by default this is `~/tmp` set in the start_<instr> command) contains the date and time of the last abortion of a `read`.

If the `abort` command has been finished, the number of frames that have been received on the workstation may be too small to create images based on that number of frames, depending on read mode (correlation type, subsampling frequency, ...) and time between starting the read and the abort.

In consequence the `save` may in general fail after `abort`. A typical example of this situation is a `lir` or `srr` mode with only two reads, where any `abort` results in only a single remaining frame (the reset frame), from which no useful information (i.e., image) can be extracted.

Special note to CARMENES programmers: Note that a command sequence like `read`, `sync` cannot be shortcut by sending `abort`, because `sync` includes a `sync read` which enters a wait state that waits until all the images of the regular integration time have arrived. This means that effectively the `abort` would be recognized *after* the `sync` returns, and at that time there is nothing left to abort. This means if you are not sure at some time whether you would like to wait for the regular passing of the full integration time or perhaps use a `abort` later, *do not* send a `sync` until you really mean it.

2 alarm

type: USER
syntax: alarm [sound] [volume]

Plays a 'General Error' sound. The 'sound' is an optional file name, where the file must reside in the `admin` subdirectory of `$CAMHOME/<version>`. 'volume' is in the range from 1 up to 100.

Note that alarm sounds cannot be blocked by setting the volume in the Options->Sound menu of the controls.

Note: On problems with the audio driver the sound may be switched off in the Options->Sound menu of the controls.

3 aperture

type: USER
syntax: aperture [name]

Move the aperture wheel to position 'name'. Actually this is only relevant to PANIC and moves the cold stop wheel (unless disabled). The named positions are defined in the files `$CAMINFO/wheel#.ext`. The available wheel indices '#' and the file extension `.ext` depend on the actual camera system in use.

If called without a parameter, `aperture` prints all possible aperture-positions and the current one.

Warning: `aperture` launches a background process and should be followed by a `sync` when used in a macro or when called externally.

4 autosave

type: USER
syntax: autosave {yes,on/no,off} [-s] [-f n] [-l n] [-r n1 n2] [-1] [-i] [-d] [-c] [-t] [[-b] or [-g]] [-p] [filename/devname] , . . .]

Enables/disables automatic `save`-operation after/during a `read`. The switches are explained with the `save`-command. If the command is used with arguments, the first one must be one of {yes,on/no,off}

If called without parameters, the current status of `autosave` is returned.

5 bias

type: ENG
syntax: bias [detN] biasname|biasindex [(DACdigits| -V voltage) [(DACdigits| -V voltage)] . . .]

For the MPIA ROE, the detector biases may be set via the detector control board by use of DAC's. Changing settings via this command is restricted to the ENG class of operators.

The HAWAII-2 (i.e., Nirvana) detector uses 3 biases (DSub, VReset, VBiasGate) and 1 external bias (extbias).

For HAWAII-2RG (Panic, Luci, CARMENES) detectors, each detector is controlled by 10 biases (DSub, VReset, VBiasGate, VnBias, VpBias, VnCasc, VpCasc, VBiasOutBuf, RefSample, RefColBuf) and 1 external bias (extbias).

These names of the biases can be written in mixed upper/lowercase characters.

The argument 'detN' is 'det1' up to 'det4', depending on the number of detectors in the camera. If 'detN' is given, the biasindex is between 1 and 10 (inclusive); If 'detN' is not given, the formula ('biasindex(1..40)'/10+1) defines the detector number. If neither 'detN' nor 'biasindex' are given, det1 or the explicit 'biasname' are used to set the destination.

If the arguments 'DACdigits' or 'Voltages' appear more than once, the first bias is addressed as shown above, and the subsequent values are written to the subsequent biases in order.

Each DACdigits is an integer between 0 and 4095.

The `-V` may also be written in lowercase `-v`.

Note that the *external* bias, one per detector, is set with `extbias`.

Examples:

```
bias det3 4 100 3248 280  #set 3 ADC-values for bias indices 24 to 26.
bias 4 100 3248 280       #set 3 ADC-values for bias indices 4 to 6.
bias 24 100 3248 280      #set 3 ADC-values for bias indices 24 to 26.
bias Vreset 3248 444      #set 2 ADC-values for bias indices 2 and 3.
bias det4 Vreset -V 2.8 3248 -V 0.5   #set 3 values for indic. 32 to 34
bias 33                   # returns status of det4 (bias indices 31..40)
bias Vreset               # returns status of det1
bias det3                 # returns status of det3
bias extbias 2300         # sets the extbias for detector1
bias det4 extbias 0       # sets the extbias for detector4
```

If called without argument, the current setting of all detectors is shown.

6 cd

type: USER
syntax: cd [directory]

Changes the directory for `save` operations, reminiscent of the UNIX `cd(1)`.

The command checks the capacity of the filesystem of the new directory. If the capacity is below some value, the command issues a warning.

If the current default filename for the save operations was given as basename ending *not* with a digit (see Chapter 40 [next], page 22), and that directory already contains files with that basename, the number part in the default filename will be increased if this is necessary to avoid name conflicts. If there is no such file in the new directory, the default filename stays as it is.

Warning: If used without an argument, the new directory is set to the home directory of the user. The directory of the 'save-path' and the free disk space in that directory are returned.

That means, to determine and check capacity of the current directory, execute `cd` or even better `pwd`. Alternatively, use `set` or `set savepath` to obtain more information on the paths.

The command may fail if someone else created the directory but did not give sufficient rights to the Unix group or others to switch to that directory.

7 clobber

type: USER
syntax: clobber {yes,no,on,off}

Enables/disables overwriting existing FITS files generated with the common `save`. The default is 'no'. The `sfdump` mechanism always overwrites files, independent of the `clobber` flag value.

If called without parameters, the current setting will be printed.

8 continue

type: USER
syntax: continue

Continues a macro and other processing of commands if paused.

9 control

type: USER
syntax: control [-x xserver] [-f font]

Opens the main camera control window (with the selection of readout parameters, the 'read' and 'save' buttons, etc).

- -x: X display in which the window is opened (e.g. xt28:0)
- -f: font-family for buttons and fields (e.g. lucida)

10 counter

type: USER
syntax: counter [name [action [set-value/incr-count]]]

Changes the named counter 'name' according to some 'action', where actions are:

- clear: or 'clr': sets the counter 'name' to 0
- incr : increments the counter (default 1)
- decr : decrements the counter (default 1)
- set : sets counter to 'set-value'

Examples: (note that the counter EXPO_NO is automatically incremented after each 'read')

```
counter    # lists the current counters and their values.
counter EXPO_NO  # shows the value of counter EXPO_NO
counter EXPO_NO clear   # sets the counter EXPO_NO to 0
counter EXPO_NO incr    # increments counter EXPO_NO
counter EXPO_NO decr 2  # decrements counter EXPO_NO by 2
counter EXPO_NO set 99  # sets the counter EXPO_NO to 99
```

Note: The next `read` will activate and increment that value to avoid interference with any concurrent and ongoing `save`. Saving the current image before a `read` will use the **old** EXPO_NO value.

11 crep

type: USER
syntax: crep [n]
syntax: crep [n [#subrep [#subrepskip]]]

Sets the cycle repeat count. This defines the number of images that will be read in a single `read` command.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see Chapter 67 [sync], page 39 .

Options not specified remain unchanged.

If called without parameters, the current status will be printed and no values will be changed. If the parameter is larger than supported by the memory allocation, it will be reduced to the count that is actually available.

If used with CARMENES note that the first pipeline stage generates at most one image for each `read`, independent of the value of `n`. Values larger than n=1 will lead to an apparent loss of data, because only the last of the read cycles will be fed into the first pipeline stage.

12 ctime

type: USER
syntax: ctime [time-val]

Returns the cycle time.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see Chapter 67 [sync], page 39 .

13 ctype

type: USER
syntax: ctype name [parameter(s)]

Sets the type of readout cycles of the ROE. The available names and options depend on the camera.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see Chapter 67 [sync], page 39 .

- Valid cycle types for Linc-Nirvana, PANIC and LUCI are: (see Standard modes of MPIA's current H2/H2RG RO-systems
  - `rr-mpia` single correlated read (like 'rr', but fast/line-rst-rd)
  - `rrr-mpia` double correlated read (like 'rrr', but fast/line-rst-rd.rd)
  - `lir` line interlaced read - a double.correlated read, (like "rrr-fmpia')
  - `msr` multiple correlated sampling read (similar 'sample-up-the-ramp'). The parameter is the number of reads on the ramp. NOTE: With 'msr,' the effective number of images is one less than the number of reads/frames on the ramp. (all other cycle types produce a single image)
  - `lir` line.interlaced.read - recommended double.correlated read, (like "rrr-fmpia')
  - `scr` single.correlated.read (similar to 'rr' (first full frame rst))
  - `dcr` double.correlated.read (similar to 'rrr' (first full frame rst))
  - `fcr` double.correlated.read (similar to 'rrr-mpia' (fast-line-rst))
  - `mer` multiple-endpoint sampling read, Fowler sampling. The parameter is the number_of_reads_per_edge
  - `srr` sample-up-the-ramp read. The parameter is the number of reads on the ramp, with a default of 2 if the parameter is not provided. If the current integration time is too short to accomodate the number of reads (for the current number of pixels, depending on the subwindow areas), the integration time may be increased by GEIRS such that the number of reads fit into the integration time (!)

    Also note that GEIRS will effectively decrease the number of samples along the ramp if the number of frames (product of the crep and the number of samples here) does not fit into the shared memory buffers as defined by the CAMSHMSZ environment variable at startup time (!)

  - `sub-xxx` subarray mode in corresponding xxx type; parameters: center-x center-y size
  - `spr` single-pixel-read, stays on the pixel and clocks as often as the field size of the channel. Parameters are the x-pos and y-pos.
  - `rlr` reset-level-read; reads the (line-)reset-level by resetting and reading the array without additional integration time.
  - `rrr-fmpia` rrr-mpia with 100perc. eff. during cycle-repeat (line oriented rd-rst-rd)
  - `subrrr-mpia` subarray in 'rrr-mpia' readout type. The three parameters are: center-x center-y size
  - `subrrr-fmpia` subarray in 'rrr-fmpia' readout type. The three parameters are: center-x center-y size
  - `mcr` multi.correlated.read (cf. 'multi', but uses coadder) The parameter is the number of reads before/after integration
  - `orm` omega.ramp.mode (cf. 'ramp'). The parameter is the number of reads on the ramp.
  - `orrr` omega.reset.read.read (cf. 'rrr', no coadder used).
  - `omult` omega.multiple.endpoints (cf. 'multi', no coadder). The parameter is the number of reads before/after integration.
- An additional cycle type for Luci2 and Carmenes is:
  - `srre` sample-up-the-ramp with embedded resets. The first parameter is the number of reads on the ramp and needs to be >=2. In the same manner as for the `srr` mode, the integration time may be increased by GEIRS if the number of reads does not fit into the integration time that was valid before selecting that mode (!) or the number of samples along the ramp may be decreased if the frames do not fit into the RAM buffers (!).

    The (optional) second parameter is the name of the ASCII configuration file that defines the geometry of the reset windows; this file name should preferably be the full path name. It plays the same role as the argument of the `-i` of `geirs_srreConfig`. (An argument equivalent to the `-p` of `geirs_srreConfig` does not exist because `ctype srre` always writes the patterns into the currently active pattern directory.) There is a modest shell-type expansion mechanism applied to the name of the configuration file, which means wild cards like the tilde (for the home directory) or $CAMBIN etc. will be recognized/expanded.

    Note that switching to this srre mode may trigger a full download of an entirely new pattern to the ROE which typically takes 18 seconds to complete and takes the same time before the command returns. GEIRS compares the age of configuration file in the file system with the last time it has updated the pattern in the ROE to decide whether such a full download is executed. External monitors need to maintain an appropriate command's timeout in the interface to GEIRS.

The set of supported modes may change with time. This set is immediately revealed in the menue after clicking on the `Read Mode` button of the controls GUI. Examples:

```
ctype srre
ctype srre 3
```

```
ctype srre 7 /home/staff/GEIRS/trunk-r731M/test/srreMask08.carmenes
ctype srre 5 $CAMBIN/../test/srreMask08.carmenes
ctype lir
ctype sfr
ctype srr 12
ctype mer 7  # GEIRS will round this up to an even number...
```

Note that instruments use only a small subset of these modes in reality.

14 define

type: USER
syntax: define [<parameter> [<specifier>]]

The `define` sets parameters. The only parameter currently implemented is 'optics'.

If GEIRS is controlled by some higher-level SW, the command is used to forward parameter values (for example concerning an optics wheel) that are not controlled by GEIRS, but still needed by GEIRS (e.g. to know the pixelscale).

The optics resolution names currently used are 'wide', 'high' and 'very-high'.

Examples:

```
define optics [ wide | high | very-high ]  # selects a resolution
define optics very           # selects the very-high resolution
define                           # prints the current parameters
define optics                # prints the optics status
```

To make impact in the FITS header, parameters need to be set before the associated `read`.

15 delay

type: ENG
syntax: delay [crep #]

Set 'delay crep x.x' before crep read. The final argument is a floating point number in milliseconds (exact to three fractional digits, ie., microseconds).

The command without argument returns the current status.

16 dir

type: USER
syntax: dir [filenames]

Executes 'ls -l' in the current directory. The output stops after each page; to proceed with the next page, enter: `<RET>`; to abort the output, enter: *q<RET>*

17 display

type: USER
syntax: display [-p[rivate_colors] or -t[ruecolor]] [-c[olors] #] [-o[verlay layer]] [-i[mg.fmt] #] [-l[ookup] table] [[-x xserver] -f font] [-n[ice] #]

Opens a GUI with the display of the detector readouts, some detector engineerig capabilities (data visualisation) and some kind of statistics of ADU variances.

- -c: # of colors {4..240} (default=100)
- -l: color-lookup-table {gray,temp,heat} (default=gray)
- -i: image size {256,512,1024} (default is 256 for Magic/CAHA and Max/UKIRT, 512 for others)
- -x: display in which the window is to be opened (e.g. xt28:0)
- -f: font-family (e.g. lucida)
- -n: nice (reduces the priority value, nice 3 is the default)
- color/-depth-usage:
  - -p: without argument: tries to get private colormap
  - -t: without argument: tries to get truecolor colormap
  - -o: without argument: tries to get visual in overlay layer

Color selection rule (results depend on the X-Server)

- default: try pseudocolor, then try truecolor, then try pseudocolor-overlay-layer

  (if a pseudocolor visual is found but results in less than (default/2)-colors of a non-private (=default) colormap, than attempt to get a pseudolor visual with a private colormap)
- with options:
  - -p : try private-pseudocolor, then try private-pseudocolor-overlay-layer then try trueflag
  - -t : try truecolor, then try pseudo-color, then try pseudocolor-overlay-layer
  - -o : try private-pseudocolor-overlay-layer

18 engstatus

type: ENG
syntax: engstatus

Requests and returns the engineering status from the camera.

There is no useful information returned if the ROE is in simulation mode. Otherwise this shows the a version stamp of the firmware (FPGA program version)

```
INFO Seen ROE3 rocon 'DETFPGA' version '3 1 7 5'
DEBUG ROE-Electronic version: 33 750 0 2 3 1 7 5;33 750 0 1 ('33 750 0 2')
INFO ROE-Electronic version: 33 750 0 2 3 1 7 5;33 750 0 1 ('33 750 0 2')
INFO ROE-Electronic version: 33 750 0 2 3 1 7 5 ('33 750 0 2')
33 750 0 2 3 1 7 5
```

19 engwindow

type: ENG
syntax: engwin

Opens a separate window that shows some parameters concerning the current pointing and read-out. The information is already shown in the control pannel (which is more up-to-date with the recent development).

20 exit

type: ENG
syntax: exit [macro]

Synonymous to the `quit` command. See Chapter 50 [quit], page 26. Shuts down GEIRS, its GUI's and servers of the camera software.

If the command is used in a macro and the argument `macro` is added, the effect is just to exit (leave) the macro at that point, but without shutting down the other parts of GEIRS. This is merely a means of type saving because it allows to ignore all the trailing lines in a macro script from some point on.

21 filter

type: USER
syntax: filter [position]

Where `position` is one of the filter macro names defined in `$CAMINFO/fmacros.instr` and the suffix .instr is actually .panic because this is the only instrument where (this version of) GEIRS steers wheels.

The macros in this file define the position of all wheels following:

- '-' means: leave this wheel wherever it is.

Syntax: In a fmacros-file, comments are started with either the semicolon (;) or with the sharp (#) and extend to the rest of the line in which they occur. Empty lines are ignored. Each other line is converted to uppercase letters for further use. In each line, a name (label) characterizing the compound filter set and the individual wheel positions are separated by any amount of white space (blanks). If there are more names than wheels in the instrument, the trailing names are ignored.

Each position (other than the star and the dash mentioned above) refers to a name in `$CAMINFO/elements.instr` and to a name in a file `$CAMINFO/wheel[0-].instr`, a set of files that enumerate wheels starting at index 0, again with the instrument's name as the suffix.

Without arguments `filter` shows all available filter macros and the current one.

`filter` starts as background process and should be followed by a `sync` when used in a macro. The `sync filter` is generally insufficient here because the recomputation of the focus offset on the telescope may cause GEIRS to emit a slave `tele pos` command which also should be waited on.

22 fits

type: USER

22.1 no option

syntax: fits

Prints the FITS-header of the most recent read buffer. If that was already saved, the command lists the header of that saving; otherwise it shows the FITS information in the current read buffer.

In the shell, the output stops after each page: to proceed with the next page, enter: `<RET>` to abort the output, enter: *q<RET>*

22.2 comment

syntax: fits comment text

Sets 'text' in the FITS header as a COMMENT.

23 get

type: USER
syntax: get varname[element] [. . .]

Reads one or more variables of the shared memory info database. When the 'varname' is an array, the entire array is listed. Alternatively, specifying an array-element in [index] reads only that single array element.

Warning: If the varname is shorted, only the first match in some internal table is returned.

In the instrument shell, a *TAB* in the command line will autocomplete or list the available arguments.

Examples:

```
get CAMERA
get ITIME
get NWHEELS
get AIRMASS
get ROTYPE
get READBUF
get CAMBUSY
get CPAR1
get CREP
get CAMPATH
get CTIME_TOT
get CMDIPPORT
get CTYPE
get DETROT90 DETXYFLIP
get FS_FCAP
```

```
get FRAMESPERIMG
get HWAWINS
get LASTFILE
get MACRONAME
get MAXIMAGES
get NIMAGE
get NPIXEL
get OBSERVER
get OBSGEO-H
get TELESCOPE
get WMACROS
get XDIM YDIM
```

The start of the current or previous exposure, the number of frames received (up to now) and the distance between nondestructive reads in the srr or srre modes can be read with

```
get INT_START_SEC
get NFRAME
get INT_DELTA_SEC
```

24 gui

type: USER
syntax: gui [-x xserver] [-f font]

Starts the graphical user interface (GUI) for the camera. For the description of the options, see Chapter 9 [control], page 4.

25 help

type: USER
syntax: help

Prints the list of commands allowed to the current class of the user.

syntax help command

prints information about the specified 'command', where

- 'syntax' describes the (various) parameters and switches.
- 'type'
  - USER: normal user command
  - ENG: engineering command, not needed for standard operations
  - SUPER: system safety critical commands. A password is required to use such a command. (the observer's name has to be the password)

Parameters in '[]' are optional. List of exclusive values are enclosed in '{}'.

26 history

type: USER

26.1 history

syntax: history
syntax !?

Print the GEIRS shell command history.

26.2 previous

syntax !!

Repeats the last GEIRS shell command.

26.3 previous search

syntax !abc

Repeats the last GEIRS shell command that starts with 'abc'.

27 idlemode

type: USER
syntax: idlemode [action] [threshold]
syntax: idlemode type [typeName]

Selects the detector's idlemode. The usual default is 'wait' with '5secs', but that depends on the instrument/camera.

Without parameters it returns the current idle mode, which shows how the `read` wout terminate the idle mode and what pattern the ROE runs on the detector while the idle mode is active.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros.

Parameter `action`

- `break` interrupts clocking of the idle mode to start the next read immediately
- `wait` completes full idle cycles and transits seamlessly from idle clocking to clocking of the readout-pattern.
- `auto` uses an integration time threshold to switch between the 'break' and 'wait' mode.

If the action is set to `auto` and a number of a `threshold` follows, the threshold should be a floating point value representing an integration time. If the integration time is shorter than the threshold, the idle mode `wait` is used, otherwise the idle mode `break.`

If the parameter `action` is set to `default`, the default idle mode of the instrument is set.

The parameter `typeName` sets the idle type. The available choices depend on the camera.
Valid idle types for Lucifer-ROE and MPIA3-ROE are:

- `default` sets the instrument default idletype
- `ReadWoConv` uses the current read-out-mode without conversion (this was the default with previous software releases)
- `Reset` fast-reset cycles
- `Rlr` reset-level-read cycles
- `Lir` fullmpia (interlvd-rd-rs-rd == lir) cycles

Examples:

```
idlemode default
idlemode type Rlr
idlemode wait
idlemode break
```

28 init

type: USER

(Re)initializes one of the three subsystems. The command will be rejected while the camera (i.e., what the readout electronics is frequently called in this manual) or the telescope subsystem are in their busy states.

28.1 camera

syntax: init camera [name] [-r] [-l #chans] [-o optics] [-s status] [-m status] [-t status]

Initialize the camera. Valid camera names and optics are defined in `$CAMHOME/src/cameratypes.h`. Camera names are not case sensitive and one of {Panic, Nirvana, Luci1, Luci2, Carmenes}.

If no `name` is given, the current settings are used and checked.

Examples:

```
init camera -r [..]  re-initializes the camera settings
        and the specified options.
init camera [..]     initializes the camera implementing/setting the defaults
```

Without the option `-r`, all options which are not set with this init command are set to default values of this camera.

With the option `-r`, all current settings of the camera remain as they are, unless they are overwritten with another option of this command.

- -l: # = {32,4} number of ADC-channels used to read detector.
- -o: optics = {wide,high,very,side,down}
- -s: status = {offline,online} (access to ROE hardware)
- -m: motors = {offline,camera,direct}
- -t: temperature-controller = {offline,camera,direct}

- -r: 'init camera name -r' does re-init but also re-setting all important last camera settings.

`Init` without parameters returns the states of the instrument parts.TBD

28.2 telescope

syntax init telescope name [-f number] [-s status]

Initialize the telescope. Valid telescope-names and focal-ratios are defined in `$CAMHOME/src/cameratypes.h`

telescope: = {lab,ca3.5m,ca2.2m,ca1.23m,lbt,none}

- -f: focal-ratio = {3,8,10,25,35,45}
- -s: status = {offline,EPICS}

28.3 wheels

syntax init wheels

Read the filter/aperture/wheel database and move all wheels to their ZERO (home) position.

29 iniwindow

type: USER
syntax: iniwin

Opens a window to setup the camera/telescope configuration. If you leave the window using the OK-button, the camera, the telescope and the wheels will be initialized if their setup was changed. The all-button forces a complete new initialization whether or not anything was changed.

30 interactive

type: ENG
syntax: interactive [{on,off,yes,no}]

If you use the interactive-mode, the outputs in the shell are blocked after 19 lines, until you enter `<RET>`. Default is 'yes'. (All shell outputs are blocking if you use interactive=yes, and you may loose messages in the shell output ring buffer, if you set interactive=no.)

31 itime

type: USER
syntax: itime [time] [-stdout / -stderr] [-o[ffset] #sec] [-m[ultiple] #sec]

Set the integration time to `time` seconds. Without any argument it prints the actual integration-time status.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see Chapter 67 [sync], page 39 .

If either the option `-stdout` or `-stderr` is added, the value is additionally printed to the associated output stream – only useful if called as `cmd_xxx itime -stdout` .

The options [-o] and [-m] are setting adjusting-factor and offset, which are used (until the value(s) are set to 0.0) according to formula: used itime = '-m'ultiple-adjustment `+` '-o'ffset

```
-o 0.0313  sets adding of constant offset of 0.0313 seconds
-m 0.020   sets adjusting itime to a multiple of 0.020 seconds
```

Rule: adjusted itime always `>=` given itime,

Exception: (adjusted-time value `<=` minimal integration time) will always set the minimal integration time.

Note: These values can be configured by the user staff via the environment variables `CAMITIME_MULT` and `CAMITIME_PLUS`, else the defaults are set to 'no adjustments', but may always be changed via this itime command from the user.

32 kill

type: USER
syntax: kill name [-w #.#]

If `name` is one of the set {display, satcheck, engwin, sdisp, gui, control, telgui, tempcon, shminfo, iniwin} then a software-terminate flag is set to the named process. All other `name` result in syntax errors.

However, setting this flag does not necessarily mean that the process is able to recognize it since the mechanism works passively (sets a flag).

If `name` is one of the set {read, save, shell, tele, wheel, filter, lyot, aperture, optics} then first a 'soft-kill' signal is sent to the process. If after timeout (default 10 seconds) the process is still alive, a 'kill -9' signal is sent to the process.

The option `-w #.#` following the process name overwrites defaulted timeout to wait for the process to terminate. The units of the parameter are seconds.

Additionally, PID-entries and serial line flags are cleared, and maybe some other flags that need a reset.

Note: If `name` is {macro}, it does not terminate the macro process, but reports only values of the macro status. If no macro process is alive, it cleans the macro status.

Warning: `kill read` should hardly ever been used in favor of `abort`.

33 lamp

type: USER
syntax: lamp ALLOFF

syntax: lamp L{1|2|3|4|5} OFF

syntax: lamp L{1|2|3|4} ON

syntax: lamp L5 ON {1|2|3|...9}

The command is only available if GEIRS is started for PANIC.

Controls the calibration lamps by executing `geirs_lamp.sh` with the syntax of the common `rflat` CAHA command. The `rflat` is executed on ultra3 if GEIRS is started with `TELESCOPE` set to `CA2.2m`, and on ultra1 if set to `3.5m`.

It seems that the `rflat` does not trigger any telescope motion.

The `geirs_lamp.sh` also writes the lamp status into a file which is scanned by GEIRS each time a new FITS file header is created.

All lamps can be switched off at once with the argument `ALLOFF`. Lamps 1 to 5 can be individually switched on or off. Lamp 5 can be switched on to a specific power which is indicated by small integer numbers in the range 1 to 9.

Examples:

```
lamp ALLOFF
lamp L3 OFF
lamp L4 ON
lamp L5 ON 3
```

34 last

type: USER
syntax: last [destfile]

Returns the filename of the most recent image that was saved and stores the filename into 'destfile'. (Relative path names are interpreted relative to the GEIRS start directory. This is considered a bug and may change in the future.)

Without the parameter, the filename is added to the file 'geirsLstFile' in the directory `$CAMTMP` (which usually is `~/tmp`).

35 load

type: USER
syntax: load filename [#n] [#incr]

Loads `n` single FITS files into the shared memory, starting with the filename given. Only images in the primary header-data-unit can be read.

If option `incr` is given this value is always added to the filename-numbering for loading the next FITS file.

The command has only been used to load a sky/background image that is subtracted from the master image in the display.

Since the shared memory frame-buffers are unsigned short integers, the image will not be correct if the FITS file is encoded with a different `BITPIX` value. (This basically means that most of the FITS files created by GEIRS cannot be read that way, because these store correlated output with 32 bits per pixel.) You also have to switch the cycle type to `reset.read` (rr) to see the image.

On negative `n`: file is added to shm.

36 log

type: USER, ENG
syntax: log [[module-] | [switch-] option(s)] [modulename | 'all' | 'MSG'] [value-str [value-str] [..]]

Controls the log-level of the software.

Only the ENG class of users is allowed to increase logging levels. The standard USER is limited to change bits in the loglevel and to switch to lower levels (but not below INFO).

Each single UNIX process can be set individually. Additionally most source-files can be set independently.

The effective log level is the 'or'ed combination of the 'main'-process module and the 'object'/source-file module in the currently running process.

A '-' (minus) sign in front of value removes that value from the setting of the selected log switch. A '+' (plus) sign in front of value adds that value to the setting of the selected log switch. Without any of the two signs in front, that value is set as the new switch. For -level, all lower loglevel are activated.

Examples:

```
log all STD              -sets all main/object levels to init-values
log all DEBUG            -sets all main/object levels to loglevel 3
log -m -l read VERBOSE   -sets for process read the loglevel to 2
log -o -b rdbase VERB1   -sets fpr object rdbase the VERB1 bits
log -o -l rdbase +TRACE  -adds for object rdbase the TRACE level
log -o -l rdbase -LOWL   -removes for object rdbase the LOWL level

log MSG +TRACE        -adds shell-outputs for all TRACE level logs
log MSG STD           -sets shell-outputs to init-state.
```

options:

- -m[main] // selects a main-process as module
- -o[bject] // selects a source-object as module
- -l[evel] // controls the logging levels
- -b[its] // controls the switches inside a level
- -h[help] // outputs all possible settings (or use tab in shell)

Modulename 'MSG': without any options sets the log-to-shell output bits. (same bit-definitions like the logbits)

Module names for the option -main:

- all - all processes are changed with the new parameter set
- read - only the read process is changed
- save - only the save process
- libplxmpia
- plxMPIA ...

Modules names for the option -object are:

- all - all modules are changed with the new parameter set
- nutil - only the nutil module is changed
- cstxlib - only the cstxlib module is changed
- rdbase - only the rdbase module is changed
- ...

Values should be given by their strings. It is also possible to use a numerical value, which will be filtered according to the level/bits options. If the number starts `0x`, it is intepreted as a hexadezimal number, if it starts `0` followed by digits as octal.

String values the for option -level (all in capitals):

- (F[ATAL],E[RROR],W[ARNING] always active loglevel 0).
- I[NFO] - log level 1
- V[ERBOSE] - log level 2
- D[EBUG] - log level 3
- T[RACE] - log level 4
- L[OWLEVEL] - log level 5

String values for the option -bits (all in capitals):

- NONE
- ALL
- STD - the standard initialisation value of the sw-switches
- DFLT - the default log switch (normal user cannot remove it)

With the option -help a listing of all value and module-names is given.

Without additional parameters `log save` gives the current state of the 'save'-modules settings. Without additional parameters, `log` alone lists all current states.

37 ls

type: USER
syntax: ls [switches] [filename]

Executes `ls` (UNIX style with options)

syntax: ls

Print contents of current `save`-directory. see Chapter 16 [dir], page 8.

The command may fail if someone else created the directory but did not give sufficient rights to the Unix group or others to switch to that directory.

```
ls aa0010.fits
ls -l aa0010.fits
ls
ls *.fits
```

38 macro

type: USER
syntax: macro [[-c[lear] | [filename]]

Executes the macro defined in the file `filename`.

If the `-c[clear]` option is given alone, the last macroname is just cleared in the parameter variable (and therefore in GUI).

The file `filename` contains command lists like any of the command shell. Be careful when invoking commands like `read`, `telescope` or `filter` that run in the background. Make sure that the next command does not conflict with the previous or use the `sync` command. The default search directory for the macros is defined in the controls-GUI by the Options–>MacroPath... or by `set macropath`.

If the filename starts with a slash '/', the directory of the `MacroPath` is not used, else the `filename` is appended to the contents of the MacroPath: If the macro `test.mac` resides in a subdirectory relative to `MacroPath`, the syntax is `macro subdir/test`.

If the given filename does not exist, the software tries to open the file after adding the extension `.mac`, and eventually also with the extension `.macro`.

If the macro file is still not found, the two default paths `$CAMHOME/MACROS/filename[.mac]` are tried thereafter. This search hierarchy allows to call standard GEIRS macros, but also to overwrite them by other macros with the same name in different directories specified by an explicit macro path.

A macro file length is currently limited to 10.000 lines and the line length limited to 255 characters.

It is possible to add comments to macros starting at a '#'. Everything from the first '#' up to the end of line is chopped before the line is executed. If the first character in a line is a '#', the entire line will be ignored.

Macros refuse to start if any motor motion, read, save or telescope command are currently active.

39 median

type: ENG
syntax: median [-r[aw]] [[-stdout] or [-stderr]] [n1 n2] [x1 y1 x2 y2]

Calculates the median of images `n1` through `n2`. Default is all images.

The options, starting with '-', must be the first parameters, i.e, must follow right after the command and before the indices of the images n[12] or the FITS coordinate specification of the rectangle, xy[12]. The four parameters of the rectangle coordinates may be given with or without the two parameters of the frame range. If the corner coordinates of the rectangle are not provided, all pixels of the image are covered.

Results are appended to the file `$CAMTMP/median.log`. The difference relative to the output in the message buffer and in the standard output or standard error output is that the file contains also the integration time [sec] in front of the median value.

Options

- `-stdout`, `-stderr` : prints the medians also to the standard output or the standard error output of the shell of the operating system. Note that this forking of the numbers to the linux shell is disabled for GEIRS running on computers with MPIA IP addresses, because printing to standard (error) output may lead to blocking channel behaviour (hangup of the entire GEIRS processing) if GEIRS has been called from the `start_geirs` Java GUI.
- `-r[aw]` : computes medians on a frame-by-frame basis for all frames in the range of the images n1 to n2. If the option is missing, images are calculated according to the type of correlation implied by the readout type that is currently active, then the medians are defined for these (correlated) images. If the option is given, the medians are computed for each of the frames that contribute to the images, so the offsets of the reset frames for example are well visible in the statistics.

Example: 'median' of 2 images in the buffer

```
median(1): 2004
median(2): 2003
ave(medians): 2003.50
```

Example: 'median -raw' of 2 double-corr. images in the buffer

```
median(1): 1004 2007
median(2): 1003     2001
ave(medians): 1003.50 2004.00
```

With the -stdout or -stderr only the resulting

```
2003.50
```

or

```
1003.50,2004.00
```

is delivered to the data streams.

Note that a richer set of information (median, minimum, maximum, standard deviation) is also obtained from FITS files on disk by calling fimgstat of the HEASoft package.

40 next

type: USER
syntax: next [-t or -n] [filename]

Sets `filename` as the default filename for the subsequent FITS files. This filename is used if the subsequent `save` commands are issued without their optional file name argument.

Automated numbering scheme of FITS files: A file name with an alphabetic letter at the end (basename) will be extended by a pattern with 4 digits. Basically a single `next` creates a name space for up to 9999 FITS files. During each `save`, GEIRS scans the current output (save) directory for files which match the pattern of the `filename` followed by four digits and the extensions .fits, _win....fits, .dump, and increases the largest 4-digit number found by 1 to create the default file name of the FITS file.

```
next hugo_
read ...
save ... # no filename, creates hugo_0001.fits if no hugo_????.fits present
read ...
save ... # no filename, creates hugo_0002.fits, because hugo_0001.fits present
read ...
save ... bastian3.fits # creates  file bastian3.fits
read ...
save ... # no filename, creates hugo_0003.fits, because hugo_0002.fits present
```

The naming scheme is preserved during `quit` (shutdown) and restart operations because GEIRS stores the active `filename` in `CAMTEMP/tmp/CAMFILENAME` during `quit` and reads it from there at startup.

Option `-t` (with or without a file name) tells GEIRS that the next `save` command should not use the default file name, but a temporary test file name. After the next `save` command the default file name is automatically reactivated, also if there was an error or problem with the `save` command. (Multiple sets of options in a single `save` command are treated as a single `save` command. This may lead to cases where the `save` cannot succeed if that implies using the same FITS file name multiple times.)

If option `-t` is given without a filename, the special name 'test' is used, else it uses the given filename. Attention: The testfile-filename is not used, if the next `save` command is given with a filename; it is only used if save is given without a filename.

To deactivate the previously commanded temporary test filename, you might either just call

```
next -n  #   without filename argument,  or
next -n filename # , where filename will be handled like above, or
next filename # , where filename will be handled like above.
```

`next` tests if the 'filename' already exists in the current path and issues a warning if this is the case. (The next `save` will then fail, if the file already exists in the current path, unless an option for overwriting (**Dangerous!**) is given.)

If `next` is used without argument, the command returns the next default and next test file names, where the one which would be used at the next `save` command is marked as 'next:'. (The 'test-filename' shows you also the starting string of the saved files, which are not queued to automatic storing to tape, etc).

41 object

type: USER

41.1 text

syntax: object text

Sets 'text' as OBJECTS in the FITS-header (truncated to 39 chars).

41.2 no option

syntax object

Prints the current object.

42 observer

type: USER

42.1 name

syntax: observer name

Sets 'name' as observer in the FITS-header (truncated to 39 chars). This name is used as password for the privileged commands.

42.2 no option

syntax observer

Prints the current observer's name.

43 optics

type: USER
syntax: optics [wheel-position]

Moves a wheel of the camera optics.

Without parameter all possible positions and the actual positions are printed.

`optics` starts a background process and should be followed by a `sync` when used in a macro.

44 pause

type: USER
syntax: pause [macro]

Stops any command execution; only continue or kill will be executed. With option `macro`, pause will only get active if a macro is found running.

Commands/macro will be continued by entering the `continue` command or may be aborted by `abort`.

45 pipe

type: SUPER
syntax: pipe [-nowait] [-list] [-timeout #secs] command [par1] [par2] [...]

Send `command` and `parameters` directly to the camera-electonics. In the simple format, no interpreation or limit checking is performed.

- -n[owait] just send command but do not wait for any answer.
- -l[ist] interprets the `command` and optionally any of the further parameters as the name of files with a command list. These file names are attached here without their instrument suffixes. The search path is the `INFO` subdirectory. In this format with the `-list`, the usual expansion of lines in the files happens: removal of comments, expansion of the multipliers, substiution of variables and so on. See the pattern constructor manual for details.
- -t[timeout] followed by an integer increases the timeout for the communication to the ROE to that number of seconds.

To turn off the front LED's of the 3 ROE boards that are under software control, for example, use the three commands

```
pipe 33 509 0
pipe 33 911 0 0x0
pipe 33 903 0 0xf
```

or to turn them on use

```
pipe 33 508 0
pipe 33 911 0 0x1
pipe 33 903 0 0x1f
```

In newer pattern versions, there are files `ledoff.*` and `ledon.*`, so to the same effect we may use

```
pipe -list ledoff
pipe -list ledon
```

46 pkginp

type: USER
syntax: pkginp [-h] [-c] [devicename]

Starts read-in process of GEIRS stream packages. Accepts only devicenames starting with `/dev/`. If no devicename is given, the devicename has to be set via the environment `PKGINPORT`, else you get an error. (should prevent accidential access of data ports just used).

- Option -h shows the command usage.
- Option -c first reads all waiting data until a timeout of a a part of a second.

47 ptime

type: ENG
syntax: ptime [#]

Sets the base time for the pixel time (which is $ptime in the roe interface).

- for observers ptime [default | slow] # sets the configured base-times for $ptime
- for engineers ptime #val # value >=0 as base-time

48 put

type: ENG

48.1 numerical

syntax: put [{-i,-f,-d,-s}] offset value

Write 'value' at 'offset' into the shared-memory infopage (database).

- -i: 'value' is an (int) (default)
- -f: 'value' is a (float)
- -d: 'value' is a (double)
- -s: 'value' is a (char*)

48.2 named

syntax: put varname[element] value [varname2[element2] value [...]]

A set of variables held in the shared memory data base may be `put` (set). The names have to match the names in the data base in full; abbreviating names is not supported.

When varname is an array, all array elements are set to value. In this case it is almost always better to adress a single element of the array with the [element] index.

In the instrument shell, a *`TAB`* will autocomplete or list the applicable varnames.

49 pwd

type: USER
syntax: pwd

Prints the current directory for the `save` operation (UNIX style) and the free space in Mbytes.

50 quit

type: USER
syntax: quit [macro]

If used without argument, the server leaves the command-shell and terminates all subprocesses (the image display, the control GUI, telescope GUIs, read and save processes ...). In that way it is synonymous to `exit`.

The effect of adding the argument `macro` within a macro is to leave the macro, but not to terminate GEIRS.

51 read

type: USER
syntax: read [-c]

Read 'crep' images according to the current cycle type, which means start the program on the ROE and read the data into the two buffers on the workstation. (If the ROE is in simulation, create some fake images instead.)

The option `-c` triggers a continuous read of `crep` images until `abort`.

`read` is a "background" process and should be paired with a `sync` when used in a macro or from a batch control program.

If `read` detects that a `read` is already running, it refuses to start, and shows (on behalf of the process that is already busy) the cycle time, repetition factor and current number of frames in the two alternating buffers in the error message.

In case that smooth termination of that `read` is not desired, one should consider sending `abort`. see Chapter 1 [abort], page 1

52 repeat

type: USER
syntax: repeat # "command arg ..."

Repeat the `command` as often as given by the integer at the hash (sharp) position. The `command` is always executed as a foreground process inside `repeat`. Background calls are not possible.

Example:

```
repeat 2 macro xyz
repeat 2 test
```

53 roe

type: USER
syntax: roe [[command] or [parameter value/string]] [-last]

Control or status of ROE and pattern parameters.

- 'default' - sets all parameters controlled by this command to the instrument default
- General options:
  - 'pread 1234' - sets pixel read time to 1234ns (nearest value)
  - 'pskip 200' - sets pixel skip time to 200ns
  - 'lskip 300' - sets line skip time to 300ns
- options
  - 'crep restart' - crep loop ROE-macro is doing the cycle-restart.
  - 'crep count' - ROE-macro only counts down the cycles seen but the cycle-loop is done by pattern-endless
  - 'crep endless' - The ROE-macro only the pattern as an endless loop and the software will top the ROE.
  - 'eop N' - N is 0 or 1, 0==continuous/1==countdown in ROE2
  - 'gap' - status of $gap, (used to exclude itimegap-pattern)
  - 'pxllns' - status of pixel-pat-table -lines
  - 'ffprot N' - N=1: ff-pers.protection (0: faster subwindowing)
  - 'oflwprot N' - N=1: overflow-persistence protection at ctype end
- commands:
  - 'verify' - checks the SW-state against the HW-state of the ROE3. Output to $CAMTMP/verify_roe3states.log.
  - 'eval' - evaluates with timing the current roe3state. Output to $CAMTMP/timing_evals.log.
- parameters:
  - 'shortint 1' - parameter 1 activates, paramaeter 0 de-activates the short subfield-integration type
  - 'ems 4' - ROE multisampling with 1, 2, or 4 samples
  - 'swms 8' - SW multisampling with 1,..,n samples (depends on RAM)
  - 'simadc 1' - activates ROE3 data simulation on ADC-FPGAs.

If the additional option '-last' in option 'crep `<string>` -last' is set, the CTIME-dependent cycle sync auto-switch is not overwriting the LAST-SYNC state for the larger cycle-times.

If used without options, the status of the ROE parameters is given.

54 rotype

type: USER
syntax: rotype [g(eirs) or fa(st) or fu(ll) or [plx] or [dgen [#dgendelayVal]]

Read-Out type of the datainterface.

The plx-type defines that data are received via the MPIA PLX-board.

The dgen-type is using the MPIA PLX-board in data-generator mode. The argument dgendelayVal is a 16-bit value: 1 selects the fastest generation and 65535 the slowest generation. (2-channel-PLX-board in 32bit/PCI-slot: 3 is max. 100Mbytes/sec, 2-channel-PLX-board in 64bit/PCI-slot: 1 is max. 167 Mbytes/sec) 4-channel-PLX-boards in 64bit/PCI-slot: 1 is max. 335 Mbytes/sec)

If the `dgendelay` is 20 and `crep` is 30, 24.8 seconds will be needed for one CARMENES read. If the `dgendelay` is 30 and `crep` is 30, 35.3 seconds will be needed for one CARMENES read.

Without arguments `rotype` shows the current status.

55 rtime

type: ENG
syntax: rtime [#]

Set the reset time, which is the number of clock tics at the beginning of each cycle-line. (MPIA electronics only.) This is not yet implemented and does nothing.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see Chapter 67 [sync], page 39 .

56 saad

type: ENG
syntax: saad x y d

Shift and add images #2 through #n. Find peak pixel around `(x,y)` in a box of size `d`. Overwrite image#1 with the result of the shift-and-add procedure.

57 satcheck

type: USER

57.1 on

syntax: satcheck on [limit]

Switches the saturation check on. The optional limit uses absolute counts of the A/D converter. These counts range from about 10000 - 55000. The non-linearity starts at about 40000 counts, which is the default limit. If 'sound' is on, you get a accoustic warning.

57.2 off

syntax satcheck off

Switches the saturation check off. This is recomended at integration times smaller than about 150 ms. (Magic-Cameras/etc)

58 save

type: USER
syntax: save [-s] [[-f n] [-l n] [-r n1 n2] [-i | -S] [-1] [-d] [-c] [-g] [-p] [-M] [-z] [-C] [filename] [, ...]]

Save frames in the shared memory according to the actual cycle type (ctype).

A comma delimits saving sets, dumping actually copies of the same data frames.

- `-s`: save immediately after image completion. Do not wait until the cycles are all completed but start saving as soon as the correlated frames have arrived.
- `-f`: save from frame 'n' (= 'first frame is')
- `-l`: save upto frame 'n' (= 'last frame is')
- `-r`: save only frames from 'n1' through 'n2'. Default is all.
- `-i`: save the integral of the selected frames. Only the sum of the pixel values over all the cycle repetitions is saved, associated with an adjustment of the integration time in the FITS header. This option is ignored for CARMENES.
- `-1`: stack all images into FITS cubes. This option has no effect if there is only one image, which means a single image still leads to the standard 2D image format.
- `-g`: split the data into single DCR-images and write to dest. The variable PKGOUTPORT provides the file name and needs to have `dif` as a substring.
- `-d`: do not create FITS-files. Just dump the shared-memory framebuffer.
- `-c`: overwrite existing files (for this save-operation only).
- `-p`: save not the actual sequence but the previous one.

  Option -p is only meant for interactive usage. It is not a good idea to use it in a macro!
- `-M`: Create images in the MEF (multi-extension FITS) format. Each subwindow is placed into an image extension of the FITS files. The primary HDU does not contain any images, only a header. The option has an additional effect for cameras with more than one detector chip: subwindows that cross chip borders are further divided along the chip borders.

  The default (not using `-M`) yields separate files with enumerating suffix _win*i*.fits. For CARMENES, however, the `-M` is always (implicitly) activated.

  If this option is combined with the `-1` option, the extensions are FITS cubes and each of these contains layers with the sucession of exposures in that subwindow.
- `-S`: Save the individual frames of what has been read, without regard of the cycle type (correlation type) that was active during the exposure. The option essentially unbundles all the implicit associations between the frames; it may be used to implement pipeline stages that act on these FITS files with refined correction methods beyond the simple add or fit schemes implemented in GEIRS.

The SAVEMODE keyword will then be set to single.frame.read and will differ from the value of the READMODE keyword. Also, the NFRAMES will refer to the single frame count, not the number of (correlating) images.

This option cannot be combined with `-i`, because `-i` explicitly requests to combine all frames into images. The option can be combined with `-M` and/or with `-1`.

Example: If

```
        save -1 -S
```

is used with the lir mode and `crep` was 3, a PANIC full frame FITS file contains a data cube of 1:4096,1:4096,1:6 pixels in the primary HDU. If the name of this FITS file is `aa_0001.fits`, the heatools command

```
     ftcopy 'aa_0001.fits[*,*,4:5]' out.fits
```

would extract slices 4 to 5 of the cube and put them into the file `out.fits` (which is created).

- `-z`: Store images as tile compressed data of the FITS standard. Only enabled if either the `-M` is also given, or if `-1` is both absent. Otherwise (`-1` without `-M`) is has has no effect.
- `-C`: Add CHECKSUM keywords to the header-data units. This is not yet implemented for all combinations of the other options. Actually the option is currently only making a difference if `-M` is also in use.

  The option is only available in the command interface, not through the submenue of the control-GUI.

  Note that use of this option assumes that all further handling of FITS files by other programs, including those triggered by the scripts in the `scripts/QueueFiles`, are checksum aware, which means, they either update the value or delete the keyword once they change keywords or data of the HDU.

  Note that the checksum is aware of the keyword notifications scheduled through the `CAMTMP/geirsPhduAdd.*` mechanism; so from this point of view it is safe to use the `geirsPhduAdd.*` files in conjunction with the `-C`.
- ` , `: space-comma-space: delimiter for a next complete save-set. (The comma is handled like a parameter-token!)

If no filename is given, the default filename is used. If the filename is given, it is advised to let that file name end on a group of digits, because default files names of files created after this one are basically chosen by incrementing the ASCII letters with some wrap around after the 9. This is fine as long as one wants to move from files A upwards to Z and from a to z and from 0 to 9, but becomes ugly if this sort of extrapolation enters the region of file names with special characters. See Chapter 40 [next], page 22.

With option `-b` the filename might be a device `/dev/pcd1`.

Example:

```
     save -p -1 , -p -i , -1 , -i
```

which saves the previous images as FITS cubes, as an integrated (summed) single fits image, the current images as FITS cubes, and the current images as integrated images.

After a save the filesystem will be checked. If the capacity is below a certain value you will get a warning from the system.

Examples:

```
     save -b -s          immediately batch-stream to PKGOUTPORT-intf.
     save -b -s filename immediatelay writes the batch-stream to a file
     save -t filename    wirtes as a single FITS-table file

     save -g -s          immediately DCR-img-stream to PKGOUTPORT-intf.
     save -g -s filename immediately DCR-img-stream to a file
```

Current PKGOUTPORT interfaces: 'dif', '/dev/PCDxx'.

`save` initiates a "background" process and should be followed by a `sync` when used in a macro. Even within a sequence of multiple `save` following each other, each individual of them ought to be followed by a `sync`, because GEIRS maintains at most one set of parameters at a time and rejects a second `save` while another one is still on its way.

If the number of frames is insufficient to create the images, `save` returns an error:

```
     Carmenescarmenes@irws2> save
     save: error: framebuffer is empty (read not yet done?)
     ERROR error: framebuffer is empty (read not yet done?)
     ERROR analyse_wait4pid: exit-status: 62 (if geirs-error: (E_noframe=62) frame-/img-buf
     ERROR 62 Command 'save' returned errorcode = 62: (E_noframe=62) frame-/img-buffer is e
     ERROR analyse_wait4pid: exit-status: 62 (if geirs-error: (E_noframe=62) frame-/img-buf
```

This happens for example in all multi-correlated image modes if the exposure was `abort`ed before a sufficient number of frames were created to combine them into an image.

59 set

type: USER

59.1 savepath

syntax: set savepath [-u] [-s] [pathname]

Echo or set the directory (path) for saving files.

If the directory does not exist, it is created.

- -u append the string of the date-format _YYYYMMDD_hhmmss to pathname
- -s create pathname as subdirectory of the current savepath `CAMPATH`

If an option is present but no pathname, the default pathname will be `data`.

The effect of defining the new directory is seen in all subsequent commands that are executed relative to the save path, for example `cd .` or `pwd` .

The command may fail if someone else created the directory but did not give sufficient rights to the GEIRS processes (i.e., to the account that starts GEIRS) to switch to that directory.

If GEIRS is shut down smoothly with `quit` as it should, the directory is stored in the file `$CAMTMP/CAMPATH` such that the next GEIRS session reads it from this file to provide the new default. Note that this mechanism of resuming the path name of the previous session

does not notice if the path name contains some indications of a formatted date. So if the path name is luci2.20131110 for example during a session in Nov. 10th, GEIRS is shut down and restarted a month later, the path name still is initially luci2.20131110 in December.

59.2 macropath

syntax: set macropath [pathname]

Echo or set the directory path for macros.

59.3 objectpath

syntax set objectpath [pathname]

Echo or set the directory path for files with object lists (user's star catalogues).

60 sfdump

type: USER
syntax: sfdump [pathname | off]

Specifies a configuration file with instructions to dump a set of windows of each single frame to a directory while in any multi-correlated or doubly-correlated read mode.

If the command is used without argument, it just returns the current name of the configuration file. This is an empty string if the dumping is not active.

If the command argument is a three-letter lower-case `off`, dumping is de-activated and the previous configuration file name is forgotten. This state is also the initial status at GEIRS startup for most instruments; for CARMENES however, the default are full frame dumps on behalf of the initial pipeline stages performed by GEIRS.

Any other argument is interpreted as a file name of a an existing, readable ASCII file with the configuration parameters. If the `pathname` starts with a slash, it is interpreted as a full path name on the GEIRS computer, otherwise as a file relative to `$CAMTMP`, and if `CAMTMP` is not defined either, relative to `$HOME/tmp`.

The configuration parameters are one per line in the file, following a FITS-style template syntax as described in the cfitsio manual:

- COMMENT [anything...] lines to be ignored, only for documentation purposes
- WIN[idx] = '[xstrt:xend,ystrt:yend]' A portion of the detector image in the standard 1-based FITS syntax. The two brackets, two colons and comma must be present as single-letters and the entire string **must** be encapsulated by quotes. The [idx] are distinct positive integers enumerating the windows.

  This window set defined by the WIN keywords usually differs from any of the sets that are specified with the `subwin`.

  The portions of the areas defined by the WIN keywords that lie outside the regions that are read out will be filled with zeros.

  If there are two WIN keywords with the same index, only the latter one (further down in the file) will be used.

  The indices do not need to be in consecutive integer order; there may be holes. (Actually all keywords that start with WIN and have a value string with the syntax of the four

  corner coordinates will be included in the window list.) If these indices are integers, they are copied into the EXTNAME of the FITS extensions for cross-identification.
- RAWF = T or F (boolean) Use a bare unsigned 16-bit binary format in the endianess of the GEIRS host, if true, otherwise a FITS format. The default is F (i.e., output file format is not raw but FITS), if this keyword is missing. The bare format has as many bytes as the number of pixels in all windows (defined above) multiplied by 2, where 2 is the number of bytes per pixel. The order of the pixels is first a block for the first window, then a block for the next window, in the order implied by the WIN keywords. In each window, pixels of the bottom line (smaller y-coordinates) come first, pixels of the top line last. Within each line of pixels the order is left-to-right (smaller x-coordinates first).
- VERB = T or F (boolean) If true, pack a standard (more complete) list of keywords into the FITS headers. This means that the GEIRS standard FITS keyword list is produced, and that also the keyword are modified according to the rules of the geirsPhduAdd files. If false, include only a minimum set of keywords. Writing the minimum set is faster, and usually sufficient if the files are anyway only scratch image files. The default (if the VERB specification is missing) is F.
- PERCT = float. If >0 and <0.9, calculate a histogram of values and add these as PERCT keywords in the assocated headers. The default (if the PERCT specification is missing) is -1, so this is disabled for performance reasons.
- FDIR = 'string' The name of a directory to which the files are written. If the keyword is missing, the default directory is CAMTMP/fits . If the string is empty, the directory is the same directory (dynamically) as where the other FITS files go. Of course this should be a directory which is cleaned up with a cron tab entry on a regular basis. The directory will be created with standard permission mask 022 if it does not exist. Of course this will fail if the GEIRS operator has insufficient write permission on any of the parent directories.
- FNAM = 'string' The base name of the files to be written. If missing, the default is an empty string. The full name of the files will be <FDIR>/<FNAME><4digitFrameNo>.fits if they are FITS files, otherwise <FDIR>/<FNAME><4digitFrameNo>. These files are overwritten if existing, independent of what has been specified with the `clobber` command.
- TSTMP = 'string' The name of a file in the FDIR which is touched after each dump. This is another passive form of signalling to monitoring processes which may poll that file's state. If missing, no such time stamp files are created. The file shows the most recently created FITS or binary file, a time stamp, and the number of subwindows (extensions) in that file.
- SUBSAMP = integer Subsampling of the frames such that not all frames collected by the computer are dumped but only a regular subset. The number of frames skipped in between (not dumped) is one less than the integer. If not specified a number of 1 (effectively no sub-sampling) is used.
- MAXSAMP = integer The maximum number of files to be created for the exposure. This is another way of defining the subsampling factor through a more dynamic interface than with the SUBSAMP keyword. If the number of frames predicted by the integer parameter of `ctype` is larger than the product of MAXSAMP by SUBSAMP,

SUBSAMP will implicitly be increased such at most MAXSAMP files will be created by the single frame dumps.

If not specified a number of 99999 (effectively no limit) is used.

- CALLB = 'string' The name of an executable to be called after the file is created. If missing or empty, no action is induced. There are two optional placeholders %s and %d in the string. The first is replaced by the name of the new file, the second by the increasing number of the frame. This string should be ending on a & to put the callback in the background. Otherwise, if the callback needs more computation time, it might block the next round of the callback to be executed. The implementation is based on system(2) calls, so redirection of its stderr and stdout need some embedding into sh calls.

Each of these configuration lines may be followed by a slash and a comment. This trailing part does not matter to GEIRS.

Header cards with other keywords than those listed above are ignored.

The line lengths in the configuration file do not matter much, but the keyword and value part must not surpass the standard 80 bytes of FITS header lines. (This effectively puts a limit on the length of the `FDIR`.)

A rough check that the configuration file is readable is made at the time `sfdump` is used. Attempts to open and read the configuration file are done later with the next `read`.

Example of a well-formed configuration file:

```
COMMENT xample file like sfdump.cfg
WIN2 = '[40:100,700:900]' / first window, EXTNAME WIN2 size 61 x 201
FDIR = '/tmp/mathar/fits' / directory of FITS SFR files
FNAM = 'sf' / the FITS files will be sf0001.fits, sf0002.fits..
WIN5 = '[80:110,700:900]' / second window, EXTNAME WIN5; overlaps with WIN2
COMMENT PIDSGL = -1
TSTMP = '/home/mathar/tmp/last' / updated with each new frame
RAWF = F / create FITS files
VERB = T / include full FITS information
SUBSAMP = 3 / dump not all but each 3rd frame (skip 2)
CALLB = 'touch /tmp/mathar/cb%d &' / shallow log trace of callbacks
COMMENT end of xample file
```

If the keyword above were changed to `RAWF = T`, files of 2*(61* 201+ 31* 201)=36984 bytes would be created.

61 sky

type: USER
syntax: sky filename

Writes the filename at keyword SKYFRAME into the FITS-header.

62 sleep

type: ENG
syntax: sleep #.#

Suspend execution of shell/macro for '#.#' seconds. This is the same as with 'sync none #.#'. (default about 2 seconds)

63 sndwin

type: USER
syntax: sndwin

Opens the sound selector-window. You may also set the volume and the output-channel.

64 sound

type: USER
syntax: sound [on|off] [-o {speaker|headphone}] [-v {0..100}]

Enables/disables sound after some operations like `read`, `filter`, `aperture`, `lyot`, `telescope`, `macro`, or as a warning if the saturation check is on. Default is 'off'.

- -o: output = {headphone,speaker}
- -v: volume = {1..100}

With some audio-players only the default volume and speaker is available. See the environemnt `CAMAUDIOPLAY` (e.g. aplay for linux) and `CAMAUDIOMIX` (e.g. aumix for linux to control main-volume).

Without parameters, `sound` prints the sound status.

65 status

type: USER
syntax: status
syntax: status -a
syntax: status -f cfg-name
syntax: status sub-status-str[;sub-status-str]...

Only one of the three listed alternatives is allowed.

Without options, `status` returns the instrument specific status list of file `status_cfg.instr`. If this file does not exist it returns all possible status information of GEIRS (like `status -a`).

- Option: [-a] returns all available parameters of GEIRS
- Option: [-f file] returns all statusses listed in file. The instrument's extension, e.g. `.lucifer`, is appended to the name if no dot '.' appears in the name.
- Option: [sub-status-string] only that specific status information

Examples:

```
status             returns parameter set defined in $CAMINFO/status_cfg.<instru>
status -a          returns all available status information of GEIRS
status -f my.cfg   returns the status set defined in file my.cfg
status subwin      returns coordinates of the 3 sets of subwindows
status roe preamp  returns only that specific status of the pre-amplifiers
status state read  tells us idle or busy (useful for monitoring)
status opmode      NORMAL (assuming ROE availabble) or ROE-SIM (software simul)
status rotype      plx (the standard online PLX data mode) or dgen etc.
status frame       plx (the standard online PLX data mode) or dgen etc.
status next        returns FITS file name to be generated next
status ctype       returns the cycle (readout type) like lir, srre etc
status crep        returns the currently active repetition factor
status itime       returns current integration time (seconds)
```

The status returned by some commands (if sent without option) may differ from the response of `status <command>` and may depend on the current context. The `subwin` command alone returns the current command status, for example!

The status information depends on the SW mode SINGLE/MAIN/INTERFACE.

The `status` command offers standardized information which is thought to be scanned by higher-level drivers.

66 subwin

type: USER
syntax: subwin clear [SW|HW]
syntax subwin [SW|auto|HW] [#wid xlstart ylstart xsize ysize]
syntax subwin on|off [SW|auto|HW] [#wid]
syntax subwin [HW|SW|DET]

Clears, enables/disables, and sets the software (SW) and/or hardware (HW) subwindows and translates them to pattern windows.

The union of the harware windows are the data send from the ROE to the GEIRS workstation via the fibers. Hardware means that the patterns run on the firmware of the ROE determine which pixels or lines of pixels are either skipped or converted while reading the detector; one of the major side effects of skipping regions is that the shortest integration time becomes shorter. Pattern windows are the sub-regions of the hardware windows repeated in each of the 32 readout channels on each detector.

The GEIRS software on the workstation can in addition cut through regions of these hardware windows it received; this post-processing we call SW windowing. (This has no further essential effect on the integration times.) The result of this 2-stage clipping (hardware, then software) are basically the pixels displayed in the GUI and saved to the FITS files.

Instead of the intricate manual SW and HW window setup there is the `auto` option, where GEIRS assumes that the SW windows are to be acquired from HW windows of minimum envelopes/areas. So the astronomer defines the result of the geometry of the software windows, and the GEIRS software converts these windows to (larger) HW windows and loads the associated pattern windows to the ROE.

Most subwin commands dealing directly with HW windows are only meant for use with detector engineering.

The order of the non-numerical parameters (clear, on, off, SW, auto, HW) can be swapped: the `on`, `off` or `clear` may also be placed after the `SW`, `auto` or `HW`.

(For performance reasons it is recommended to define first the list of SW windows, then to activate the windows via a single `subwin on auto`. Background: computation of the pattern windows and the communication with the ROE is inactive as long as the subwins remain "off." So one can delay that computation by defining the geometries in the "off" state to switch them "on" only once at the end.)

`subwin on auto` will clear all HW windows and then redefine the HW windows for the instrument via the currently defined list of SW windows.

If the instrument has no HW windows defined/enabled, full frames are read out and windows are generated by SW windowing.

Subwindows are only added, if the list of subwindows is not yet full and '#wid' number is not yet used for a subwindow, where '#wid' of SW windows are overwriting any '#wid' of HW window definition. But if only HW windowing is used the '#wid' of the HW-window definition is used.

Currently the max. subwindows count per list (SW/HW/DET/PAT) is fixed in GEIRS and is at least a multiple (>2) of the data channels of the detector, currently >= 5*128.

xlstart and ylstart are the Cartesian coordinates in FITS style, i.e., each >=1 and with (1,1) addressing the lower left pixel in the full frame image. The four coordinates refer to the natural global FITS coordinate system, which stretches from the lower left corner of the lower left chip in the detector mosaic to the upper right corner of the upper right chip.

xsize and ysize are width (>=1) and height (>=1) of the window in units of pixels. Because there is a block buffer size of 512 Bytes configured in the OPTPCIe setup, GEIRS rounds the two sizes up such that the product is a multiple of 8 pixels, therefore a multiple of 16 bytes, such that the total over all 32 readout channels of each chip is a multiple of 512 bytes. This means the windows shown in the FITS files may be sligthly larger than the parameters `xsize` and `ysize` submitted by the observer.

If the region of a user window stretches beyond the current detector area (2048x2048 for LN or Luci, 4096x4096 for PANIC and 4096x2048 for CARMENES), the software issues a warning and chops off the pixels that fall outside that detector area.

The software windows with different #wid indices may overlap.

There are two variants of handling subwindows that by the operator's layout stretch across different detector chips:

- If the code has been compiled with the preprocessor variable GEIRS_FITS_KEEP_SWWIN_ENUM defined in `Makefile.am`, GEIRS refuses to accept windows that have pixels on different chips. Also the operator's integer enumeration of the software windows here in the `subwin` command is carried over to the name convention of FITS files and the EXTNAME definition in MEF files. (This is the default for all instruments.)
- If otherwise the code has been compiled without the preprocessor variable GEIRS_FITS_KEEP_SWWIN_ENUM defined in `Makefile.am`, GEIRS splits and re-enumerates windows that have pixels on different chips. The windows are then

enumerated contiguously from 1 upwards in the FITS file name and EXTNAME values.

The software windows are independent of (not shared with) the window set of the `sfdump` command and/or the set of the "reset" windows associated with the srre mode.

The command `subwin` without any parameter shows how many windows of which kind are currently defined and activated.

If the `subwin` command changes the set of window geometries, the main GUI with the images usually shows intermediate garbage until new data have been generated with `read` (because the `subwin` commands modify the index tables which translate the positions of data in the serial frame buffer of the detector frames of the past into positions of data in the serialized 2D geometry in the GUI, and these do not match until the new detector frames have been generated.)

Examples:

- activation control:

```
subwin off   Any windowing is switched off, resumes full frame
subwin on    HW and SW windowing with current subwindow geometries activated
subwin on SW     SW windowing will be used
subwin off HW    HW windowing will not be used
subwin off SW 1  Deactivate SW window number 1
subwin on  SW 2  Activate a previously deactived SW window number 2
```

- definition of window geometries:

```
subwin SW 12 1 1 100 100   define geometry of SW window number 12 of dimension
                 100 by 100 starting at the left lower edge 1,1 and append
                 it to the list of SW windows, according to unique
                 #wid=12 and available window definition free space.
subwin HW 12 1 1 320 10        HW window with #wid=12
```

- clearance of window geometries:

```
subwin clear     Clear all windowing definitions
subwin clear HW  Clear all HW windowing definitions
subwin clear SW  Clear all SW windowing definitions
```

Important:

- Just setting the windows coordinates does not activate windowing. An explicit `subwin on` is still needed.
- Removing a single subwindow from the list of known subwindows is not possible. It is only possible to deactive all of them. Still the deactivation needs to be followed by a `subwin auto on`.

AND: If subwindowing is switched on, each subwin command needs to recalculate the whole subwin-logic. Therefore it is always a good idea to execute first `subwin off` before changing subwin properties.

Recommended command sequences:

```
subwin off     # Deactivates subwindowing. The rationale is that
               # if subwin is on, each command has to recalculate
               # all windows. So with the "off" we avoid that the next
```

```
                # two "subwin" each recalculate windows before the full
                # set of windows has been defined.
[subwin clear    # clears/forgets all tables of previous windows]
subwin SW 1 100 100 200 300  # define/add first subwindow with coordinates
subwin SW 2 300 300 200 300  # define/add second subwindow with coordinates
subwin auto on  # recalculate and activate the HW/DET windows
[subwin SW off] # display/save/use all hardware windows
```

Example: Splitting the full area of the PANIC mosaic into four windows such that they appear as four different images (even if the MEF option of the `savev` is not used):

```
subwin off
subwin clear
subwin SW 1 1 1 2048 2048
subwin SW 2 2049 1 2048 2048
subwin SW 3 1 2049 2048 2048
subwin SW 4 2049 2049 2048 2048
subwin SW on
```

A quick way of switching to full frame mode, generating images, and returning to the previous set of subwindows is implemented with the following scheme:

```
subwin off      # deactivates all subwindows (now fullframe)
...
subwin on       # re-activates the previous subwindows
(or: subwin auto on # recalculates the HW/DET windows
```

Disable a single software window that was defined earlier:

```
subwin off
subwin SW 99 off   # disables the softweare windwo with id=99
subwin auto on  # activates the windows; window id=99 is now absent
```

Enable a single disabled SW window:

```
subwin off
subwin SW 99 on    # enables the SW win of id=99
subwin auto on  # activates the HW/DET wins, including id=99
```

`subwin` without any parameters or with HW or SW or DET as parameters prints the current settings.

67 sync

type: USER
syntax: sync [[read] [tele] [filter] [save] [test]] [[none] [all] [macro]] [#.#time]
syntax: sync -e

Waits until the background processes named by the arguments have terminated.

The model of the command execution means that these background processes reply with an early response to their command. These processes `read`, `tele` and so on are in some sort of common group because they need some time until they finish. After starting any of these processes, commands like `status` and `get` could be used to monitor how far which of these

processes have proceeded. The `sync` finally is actually waiting until these processes have finished (in some cases triggered by individual timeouts), and responds which the information collected by the processes during their execution as parallel background processes.

Think of the `sync` as blocking/delaying all followup commands (even `abort!`) until `sync` itself returns. In practise this means do *not* send a `sync` if you may wish to `abort` the `read` at some time in the future.

It returns the last errors of the background processes. If no name or `all` are specified, these are all errors, otherwise the errors of the process specified by the command. This allows to watch immediately the error of a background process.

At each start of a background process it clears its last error.

To clear all last errors of any background process use `sync -e`.

`sync -e [#.#time]` waits like `sync all [#.#time]` but clears on return all previous errors of the background processes.

#.#time: int/float-value as last argument:
sync waits at least '#.#' seconds, before checking on any process to synchronize with. This is a mean to ensure that even on a busy system a just scheduled command has indeed started (which may need some time).

If the argument `none` is present, it does *not* sync with processes, *even if* process names are in the argument list.

If no process parameter is given, `sync` waits for the termination of all five background processes listed above and currently running in the system, but not on the `macro` process.

Without the `#time` specification the sync waits at least 2 seconds. The signature `#.#` indicates that this duration may be specified in a floating point format.

Examples

```
sync    - synchronizes with all background processes after
          waiting a default time .
sync 1.5   - synchronizes with all background processes after
              waiting 1.5 seconds.
sync none 0.5   - just waiting 0.5 seconds (no syncs at all!)
```

This command is needed for writing macros, since commands like `read` do not block the execution of the next command. A typical sequence could look like this:

```
sync -e 0.1          # start of sequence clears last errors
read                 # read data
sync                 # wait for all still running processes
tele rel 10 10       # move telescope 10" north, 10" east
save -f 2 -i         # save data
sync tele            # wait for the telecope movement
read                 # next 2nd read
sync read            # wait for read process
tele rel -10 -10     # move telescope -10" north, -10" east
sync save            # wait for 1st save end
save -f 2 -i         # save next data of 2nd read
sync tele            # wait for tele-movement done
read                 # next 3rd read
```

```
...
```

If a parameter of `sync` is `macro` or `all` and the `sync` is started from inside of a macro, this `macro` or `all` string is just removed.

`sync macro` waits only as a command outside of a macro on the termination of the main macro-level.

`sync all` waits on all processes including the `macro` process. `sync none` waits on neither process, only waits for the given time (or 2 seconds for default).

A note on the instruments where GEIRS steers motors: Motor movements may in general result in a decision to update the CAHA telescope offset if the wheels' configuration files indicate that the total contribution to the focal shift is larger than some minimum. In these cases `sync wheel` pauses until the motor motion is finished but does not wait until the telescope command is finished. It is therefore good practise not to use an isolated `sync wheel` but either `sync` or a combined `sync wheel` and `sync tele`.

Note: If a background process hangs or died in an unexpected way, it might be necessary to use a `kill [background-process]` command to let the `sync` command return.

68 system

type: USER
syntax: system [']cmd[']

Executes any system command, where `cmd` might be any combination of arguments. On problems with special characters surround the cmd with the character `'`. Example

```
system 'tvgcmd 0 "\033"'   to send escape to tv-guider.
system tvgcmd              to get information about tvgcmd.
```

Waits for termination of the system call.

69 tdebug

type: USER
syntax: tdebug [text [anytext [anytext[]]

Writes an entry into the debug_${user}.log file in the format '2004-05-28 11:23:41.3794 ZD account (logentry) alltext"

Alltext (limited to roughly 2048-8192 chars) is the concatenation of all the arguments.

70 telescope

type: USER

Only relevant for Calar Alto instruments that control telescope pointing via GEIRS (i.e., PANIC). For the other instruments the command only has the effect of setting the sky coordinates in GEIRS's internal data base such that they appear in FITS headers (unless removed by the `geirsPhduAdd` files).

Besides the specific errors listed below, the telescope interface may return the following error codes:

- 1 TELESCOPE environment variable incorrect.
- 2 Cannot communicate with EPICS
- 3 Wrong t_script command
- 4 Bad number of arguments
- 5 TELESCOPE environment variable not set.
- 20 Tracking is OFF.

Warning: These error codes are copied from a file distributed to a private list of users by the head of the Calar Alto computer department in 10/2014. They are not under GEIRS control and may change at any time if Calar Alto changes the associated Tcl scripts.

The time out durations are set within the subcommands of the `t_command` and in that sense not controled by GEIRS.

70.1 absolute

syntax: tele[scope] abs[solute] hr min sec deg min sec [equinox]

Moves the telescope to an absolute RA/DEC position. `hr`, `min` and `sec` are the alpha coordinate. `deg`, `min` and `sec` are the delta coordinate.

GEIRS does not check validity or ranges of any of the 6 or 7 numerical parameters, but forwards them to the `t_command t_posit` after rounding `hr`, `min` and `deg` down to integer. If at least one of the `deg`, `min` or `sec` parameters has a negative sign, the sign is moved to the `deg` parameter before submitting it to `t_command`.

If the `equinox` is not provided, GEIRS inserts a value equivalent to now (when the command is executed). This may not be not what the astronomer wants, but is compatible with the software run on CAHA for earlier Omega cameras. It has been argued that the telescope control software uses the `equinox` to correct for some Earth polar motions; the author of this manual here has no opinion on this.

The telescope interface may return the following error codes:

- 40 Incorrect alpha value.
- 41 Incorrect delta value.
- 42 Incorrect epoch.
- 43 Position not reached.
- 44 Telescope keeps on moving.
- 45 Timeout when moving the telescope.

70.2 relative

syntax tele[scope] rel[ative] [[zero] or [dalpha ddelta]]

Moves the telescope by `dalpha` and `ddelta` arc-seconds. The numerical value of `dalpha` is supposed to include the factor cos(delta) of the current position. (It is removed by GEIRS by division through the cosine before presenting the value to the `t_command t_offset`, which expects a number in the pure right ascension.) *The supposed advantage of this manoevre is that the dithering motions of the instrument can use essentially fixed strides all over the sky. Again, this appears to be mainly for compatibility with earlier cameras.*

```
'tele rel zero': sets the relative offset sum to zero
'tele rel':      shows the relative offset sum.
```

The telescope interface may return the following error codes:

- 50 Incorrect value in the alpha offset
- 51 Incorrect value in the delta offset
- 52 Alpha and delta positions not reached
- 53 Alpha position not reached
- 54 Delta position not reached
- 55 Timeout while moving to position

`tele` is a `"background"` process and should have a `sync` after it.

70.3 focus

syntax tele[scope] focus [#]

Move the telescope focus by # units (i.e., microns) by sending `t_command t_dfocus` to the telescope.

Note that it is impossible (due to some intrinsics of the t_dfocus interface in the CAHA scripting) to move to a focus position that has a negative value on the absolute focus scale. Example: If the focus position is at 5 units before the move request, and if the argument `focus` to this command is -7, the desired final focus position would be -2, and that negative value cannot be accomplished.

The telescope interface may return the following error codes:

- 30 Incorrect value for the relative focus motion.
- 31 Position not reached.
- 32 Timeout while moving to focus.

At the final stage of each motor motion (individually or in groups via the `filter`), the telescope focus is changed from within the motor procedure (unless disabled or the sum of the focus corrections of the previous and new filters are too small and so on.) It is therefore **not** recommended to issue a `tele focus` while motors are still in motion.

70.4 query

syntax tele[scope] pos[ition]

Reports the telescope coordinates (alpha, delta, hour angle and air mass) by sending `t_command t_request` to the telescope.

70.5 extended query

syntax tele[scope] get[allpositions]

Requests `tele pos` and `tele focus` combined.

70.6 TECS

syntax tele[scope]

Return telescope name and TECS status read from SW database, which means it might not be up-to-date/the current one.

The following command series returns a more reliable/up-to-date status information:

```
'tele get; sync tele 0.5; status tele [get]'
```

The `tele` command in this form without argument and the `status tele` do not need a `sync`, as they are only reading a status and do not call a 'tele' function.

71 telgui

type: USER
syntax: telgui [-x xserver] [-f font]

Starts a graphical user interface (GUI) to the telescope. Only used for Calar Alto instruments that control telescope pointing via GEIRS.

- -x: X-terminal or X-server name to connect to.
- -f: font name for menus and buttons

72 tempcontrol

type: USER
syntax: tempc(on) [-x xserver] [-f font]

Starts the LakeShore temperature controller and logger. Only used for instruments that are actually controling such a device via GEIRS.

- -x: X-display name where the window is created (e.g. xt28:0)
- -f: font-family for the display (e.g. lucida)

73 temphistory

type: USER
syntax: temph file [-x time1 time2] [-f time1] [-y temp1 temp2] [-d xserver]

Same syntax and actions as for `tempp`. see Chapter 74 [tempplot], page 45

74 tempplot

type: USER
syntax: tempp file {[-x time1 time2],[-f time]} [-y temp1 temp2] [-d xserver]

Creates a X11 window plotting temperatures from the log file (that was created by `tempcon`). Only relevant to some Calar Alto instruments that have log files in the GEIRS format.

The horizontal axis are minutes, the vertical axis are temperatures [Kelvin].

- -x: time1/time2 = begin/end time on the horizonal axis.
- -f: time= begin time on the horizonal axis
- -y: temp1/temp2 = cuts of lower/upper temperatures in the graph
- -d: display on which the window is opened (e.g. xt28:0)

This window will *not* be closed when the software is shut-down with the `quit` command.

75 test

type: ENG
syntax: test {std,med,var} [-q #] [[-r n1 n2] or [-r1 n1]]

Computes pixel statistics and appends the result to the file `chiptest.log` either in `$CAMTMP` (usually `~/tmp`) or in the current directory:

- std: prints averages and deviations over all pixels in all images of each channel and the same for the full image (with additional stdv of channels-stdv). This is the default option if neither `med` nor `var` are used.
- med: prints the median of all channels of each image
- var: prints the median of all pixel-averages as a function of time, and the median of all pixel-variances as a function of time. (Note: this throws an error if less than 2 images are available!)

Default: the log file shows results channel-by-channel. The channel order follows the default orientation of each detector, independent on the user's flips or rotations. That means the channel enumeration is usually not trivially related to the display orientation.

Options:

- -m: for 'test var' : de-activates median of variances independent of median-pixel of averages (takes it from the average-pixel) Default: variance is taken as independent median value.
- -r n1 n2 : use images `n1` through `n2` (e.g. 'test var -r 2 11')
- -r1 n1 : use images `n1` through the last (e.g. 'test var -r1 2')
- -s : use the software subwins for the tests if activated. Instead of the default statistics looking at the quadrants, the statistics is done by subwindow.
- -q # : use only quadrant or output-channel or SW-subwindow number '#', where the numbering starts at 1 (e.g. 'test var -q 1'). This option is only available with the `var` parameter.

Warning: the combination `-s -q` is not allowed.

If the `-s` option is not used, all HW-read data are accumulated to get the statistics. With the -s option, statitics is calculated in SW-subwindows, ignoring in which HW channels these are located.

The defaulted output of the command 'std' for PYRAMIR (4 channels) for example is:

```
test std          mean & stdv & n ( 4 outputs, 10 images, \
           ctype rrr-mpia, camera Pyramir, itime 1.000000, \
           ctime 1.186678, FULL-frame 1, npixel 1048576)
   output#1:        2004.20  3.839          2621440
   ...
   output#4:        2004.32  3.921          2621440
   output##:        2004.31  3.947  0.121         4
```

which shows for each ADC-channel the mean, standard devtion and pixel count. The final line in the output on the GEIRS shell is the 'output##' line with the 'mean of means', the 'mean of stddevs' over the channels, and the 'stddev of the channel-stddevs'.

76 use

type: USER
syntax: use [[ctype] or [<ctype> [corrupted, atleast, skip] [#frames]]

`use ctype` sets some parameters for the calculation of the given cycle type, given in units of single frame readouts. Currently this is only used for the mcr (multi-correlated) types, srr(e)/cntsr, lisrr/licntsr.

Examples:

```
use ctype              # list the parameters of all ctypes
use cntsr corrupted 3  # do not use the last 3 frames before ABORT
use cntsr atleast 10   # use the aborted image if at least
                         # 10 frames (default at least 2) are usable
use cntsr skip 2  # drop the first 2 frames of any cntsr cycle

Usable frames are only checked for an aborted image. It is:
     (#_of_read_frames - #_of_corrupted_frames - #_of_skip_frames)
```

The syntax without argument just returns the current status.

77 ustatus

type: ENG
syntax: ustatus

Returns the user status, one of {astronomer,engineering,superuser}

78 verbose

type: USER
syntax: verbose {on,off,yes,no}

`verbose yes` increases the amount of output to the shell.

While executing a macro, for example, the system will print every command (and its line number), so the operator always knows which marco line is being executed. Default is `yes`. If no parameter is provided, `verbose` prints the value of the verbose flag.

79 version

type: USER
syntax: version

Returns the version string of the GEIRS software.

80 wheel

type: USER

80.1 Basic use

syntax: wheel [#wheel [[position-name]

Only relevant to some Calar Alto instruments that control motorized wheels by GEIRS.

Move wheel number '#' to the named position or return the status information. The '#' is the wheel number from 0 up to n (inclusive), as shown by the answer of the command `wheel` if used without arguments. Examples:.

```
wheel                  Returns overview of all wheels;
              reads and displays current wheel-positions.
wheel 2                Returns information on wheel 2.
wheel 2 wollaston45    Moves wheel2 to the wollaston45 position.
```

If the wheel number is replaced by the string `aperture`, the command addresses the first wheel that is in the `aper` class in the `INFO/wheel?.*` files. For PANIC this is actually the cold-stop wheel.

`wheel` becomes a background process and should be followed by a `sync` if called from within a macro.

80.2 focus

syntax: wheel focus [on,off,new]

`wheel focus [on/off/new]` controls the relative focus adjustment for the selected combination of elements. Example:

```
'wheel focus off'   deactivates the focus correction of all
       filter-wheels for the subsequent wheel/filter commands,
       until it is reactivated.
```

Example:

```
'wheel focus on'  (re-)activates the focus correction for
         the subsequent filter wheel commands, which are tagged
         for CHKFOCUS-correction in the wheelN.<instrument>
         configuration files.
```

Example:

```
'wheel focus new'  updates the relative focus correction
         information to the current wheel positions, for all filters
         which are tagged via CHKFOCUS correction in the
         wheelN.<instrument> configuration files. Note that this
         call does *not* change the on/off state!
```

Focus correction is always done relative to the last filter combination which was saved at the last filter-correction action.

Application note: Focus settings beyond the wheel focus control through the program will remain correct and will lead to correct relative focus corrections, as long as neither wheel/filter exchanges nor manual focus-changes occur while the GEIRS state is 'wheel focus off':

– To enable the correction of the relative wheel focus, after wheel changes *and* manual focus settings had been done in 'off' state, use `wheel focus new` to discard the previous information on the relative focus correction that was remembered by the server, and to update it with the current focus.
– initialisation of wheels does not change focus, but activates the focus correction for the next wheel usage. (At initialisation time the focus correction is correct.)

80.3 relative

syntax: wheel [#wheel relative #offsetsteps]

```
wheel 2 rel -25         Moves wheel2 25 steps backwards.
```

80.4 init

syntax: wheel init

80.5 warminit

syntax: wheel initwarm

80.6 dialog

syntax wheel dialog [on,off]

The syntax with `dialog on` or `dialog off` enables or disables warning and error GUI's. Dialogs are usually shut off if GEIRS is driven by an external handler and there is no operator that could click on the buttons.

80.7 rdb

syntax: wheel rdb

`wheel rdb` re-reads the wheel and wheel-macro database files.

80.8 aperture

syntax: wheel aperture

Yields a list of wheels in the aperture class. For PANIC this is the cold stop wheel.

80.9 optics

syntax: wheel optics

Yields a list of wheels in the optics class. For PANIC this list is empty.

80.10 filter

syntax: wheel filter

Provides a list of filter macro positions.

81 xserver

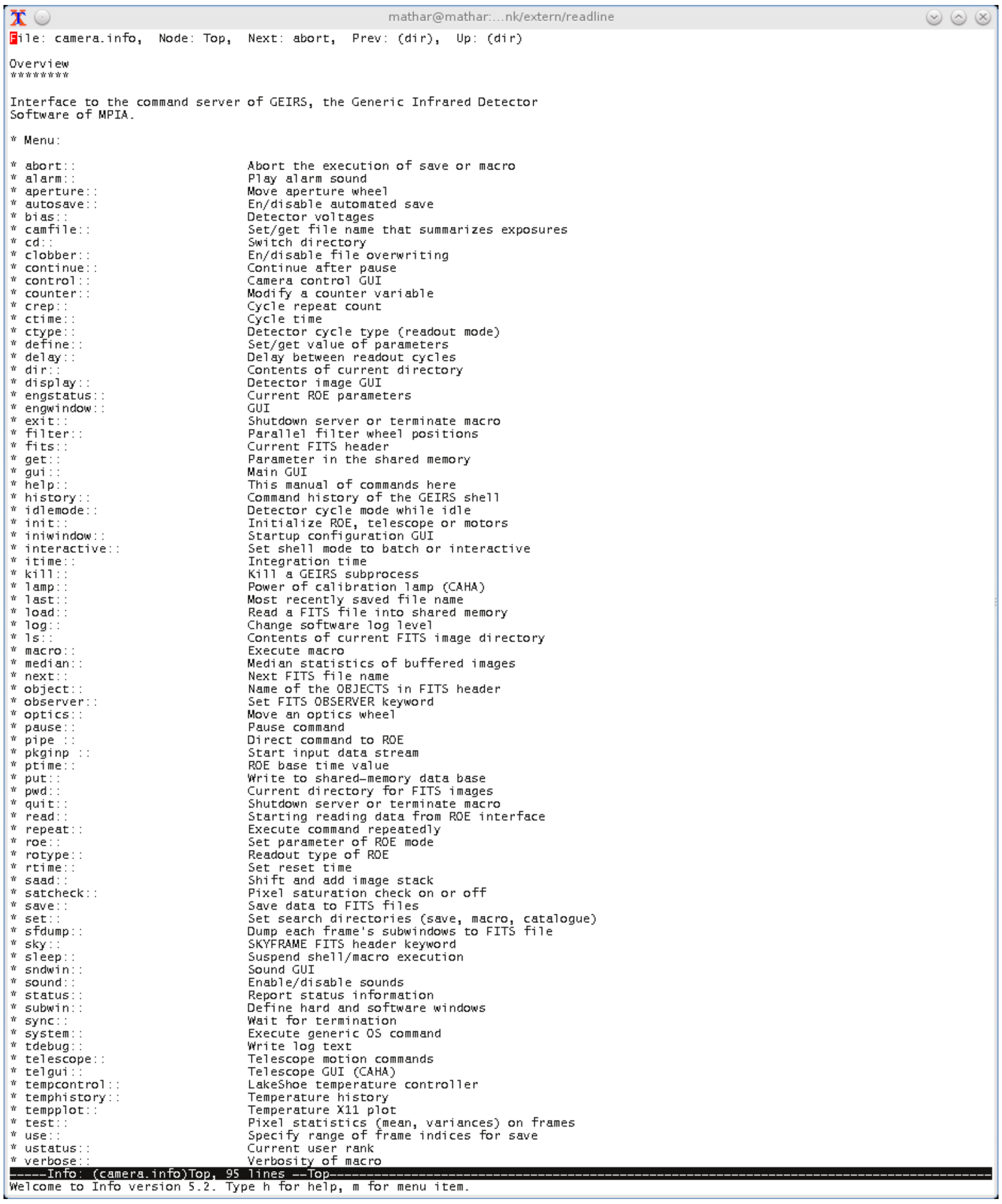
type: USER
syntax: xserver [xserver]

Set default X-display (X-server) name as the default for subsequent displays. At startup of GEIRS, the initial value is taken from the DISPLAY variable of the startup shell.

If used without argument, the command shows the current value.

Index

(Index is nonexistent)



```
File: camera.info,  Node: Top,  Next: abort,  Prev: (dir),  Up: (dir)

Overview
********

Interface to the command server of GEIRS, the Generic Infrared Detector
Software of MPIA.

* Menu:

* abort::                       Abort the execution of save or macro
* alarm::                       Play alarm sound
* aperture::                    Move aperture wheel
* autosave::                    En/disable automated save
* bias::                        Detector voltages
* camfile::                     Set/get file name that summarizes exposures
* cd::                          Switch directory
* clobber::                     En/disable file overwriting
* continue::                    Continue after pause
* control::                     Camera control GUI
* counter::                     Modify a counter variable
* crep::                        Cycle repeat count
* ctime::                       Cycle time
* ctype::                       Detector cycle type (readout mode)
* define::                      Set/get value of parameters
* delay::                       Delay between readout cycles
* dir::                         Contents of current directory
* display::                     Detector image GUI
* engstatus::                   Current ROE parameters
* engwindow::                   GUI
* exit::                        Shutdown server or terminate macro
* filter::                      Parallel filter wheel positions
* fits::                        Current FITS header
* get::                         Parameter in the shared memory
* gui::                         Main GUI
* help::                        This manual of commands here
* history::                     Command history of the GEIRS shell
* idlemode::                    Detector cycle mode while idle
* init::                        Initialize ROE, telescope or motors
* iniwindow::                   Startup configuration GUI
* interactive::                 Set shell mode to batch or interactive
* itime::                       Integration time
* kill::                        Kill a GEIRS subprocess
* lamp::                        Power of calibration lamp (CAHA)
* last::                        Most recently saved file name
* load::                        Read a FITS file into shared memory
* log::                         Change software log level
* ls::                          Contents of current FITS image directory
* macro::                       Execute macro
* median::                      Median statistics of buffered images
* next::                        Next FITS file name
* object::                      Name of the OBJECTS in FITS header
* observer::                    Set FITS OBSERVER keyword
* optics::                      Move an optics wheel
* pause::                       Pause command
* pipe ::                       Direct command to ROE
* pkginp ::                     Start input data stream
* ptime::                       ROE base time value
* put::                         Write to shared-memory data base
* pwd::                         Current directory for FITS images
* quit::                        Shutdown server or terminate macro
* read::                        Starting reading data from ROE interface
* repeat::                      Execute command repeatedly
* roe::                         Set parameter of ROE mode
* rotype::                      Readout type of ROE
* rtime::                       Set reset time
* saad::                        Shift and add image stack
* satcheck::                    Pixel saturation check on or off
* save::                        Save data to FITS files
* set::                         Set search directories (save, macro, catalogue)
* sfdump::                      Dump each frame's subwindows to FITS file
* sky::                         SKYFRAME FITS header keyword
* sleep::                       Suspend shell/macro execution
* sndwin::                      Sound GUI
* sound::                       Enable/disable sounds
* status::                      Report status information
* subwin::                      Define hard and software windows
* sync::                        Wait for termination
* system::                      Execute generic OS command
* tdebug::                      Write log text
* telescope::                   Telescope motion commands
* telgui::                      Telescope GUI (CAHA)
* tempcontrol::                 LakeShoe temperature controller
* temphistory::                 Temperature history
* tempplot::                    Temperature X11 plot
* test::                        Pixel statistics (mean, variances) on frames
* use::                         Specify range of frame indices for save
* ustatus::                     Current user rank
* verbose::                     Verbosity of macro
-----Info: (camera.info)Top, 95 lines --Top------------------------------------------------------------------
Welcome to Info version 5.2. Type h for help, m for menu item.
```

Figure 29: Example of the window opening if `info camera` is called from the Linux shell.

5.4 Macros

5.4.1 Aim and Configuration

Macro files are prepared to carry out specific, normally reoccurring, tasks in the spirit of batch processing. The macro utility is sequentially oriented; each line in the macro file contains a command of the set of Section 5.3 for every action normally assembled by using the camera GUI or typing commandos into the GEIRS shell.

Empty lines in the macro file are ignored/skipped. The part of lines starting at a hash (`#`) up to the end of the line is chopped—and serves to add comments to the macro files. The maximum line length in the macro files is 256 bytes.

The syntax does not provide conditional and loop capabilities beyond the `repeat` command of the GEIRS shell itself. In that respect it does not extend the command interface.

Macros can be nested 5 levels deep, so the `macro` command may appear in a macro file. The most economic way to loop through a set of fixed commands a fixed number of times is to write this set into a macro file, then to call this macro from another "higher level" macro as many times as wished. In any way, these techniques are based on working with copy-n-paste on the ASCII files of the macros.

Every macro command may be issued with the prefix `cmd_carmenes` from a UNIX/Linux shell or with `$cmd_carmenes` from MIDAS.

Macro files are started from the camera control window (lower part, see Figure 6) or with the `macro` command to the instrument shell. As a matter of orderly book-keeping, it is recommended to use the file suffix `.mac` for all macro files. GEIRS searches first for the macro file with the exact name provided by the user, and then searches in addition (as a fallback) for that exact name augmented by `.mac`. So one may lazily use the file name without suffix in the GUI of Figure 6 and after the `macro` command if file names in the directories do have the `.mac` suffix.

The "macro path" plays the role of a search path for these `*.mac` files. It is set/changed with the third pull-down menue of Figure 6 or the associated `set macropath` GEIRS shell command, and saved across GEIRS shutdown/startup cycles in the file `$CAMTMP/CAMMACROS`. If a macro file is not found in that directory defined by the search path, GEIRS also searches thereafter through `$CAMHOME/MACROS` by default. If users store their macros in that `MACROS` subdirectory anyway, the "macro path" is not that relevant.

The macro files support DOS-style end-of-line markers of the composite carriage-return and line-feed bytes. In that respect one can copy these files from older Microsoft operating systems without using `dos2unix(1)`. UTF-16 encoding of the newer Microsoft OS's is not supported and supposed to be converted by tools like `recode(1)` before feeding them into GEIRS.

5.4.2 Syntax Checker

A basic syntax checker for a macro file is called with

`geirs_MChk` *macrofilename.mac*

which tests many (but not all) lines in the macro file for syntactical correctness. `geirs_MChk` prints the lines that appear to be incorrect to standard output. It checks only the most common commands that appear in macros. Commands like `status`, `ls` and other commands that produce detailed output or open windows that needs interpretation by some listening program and do not make much sense in macros are also reported. Numerical parameter ranges are only checked by order of magnitude, or even not at all.

Checking all macros in a subdirectory is done with a loop in some bash shell similar to

```
cd $CAMHOME/MACROS
for f in *.mac ; do
    echo $f"..."
    $CAMBIN/geirs_MChk $f
done
```

The main benefit of using the checker is that typographic errors may be detected early, just after editing the macro file. The GEIRS macro interpreter reads one macro line at a time and executes it. If the total real time of executing the macro is long, errors in its late parts may lead to much delayed abortion of the macro. A syntax checker adds some safety and time savings in that type of scenario.

5.4.3 Total Integration Time

The total integration time in a macro is a sum over all products of the `crep` arguments and the `itime` arguments that are active at the `read`. It can be calculated by calling

`geirs_MItime.pl` *[-q] macrofilename.mac*

Using the *-q* option gives a more quiet output, where the partial sums are not printed. The *macrofilename.mac* is either a full path name or the name in the current working directory. If that file is not found and the CAMHOME environment variable is set, the program tries to locate the file also in the directory $CAMHOME/MACROS.

This scanner looks for lines of the format

`itime` *seconds*

`crep` *count*

`read`

`quit`

`exit`

`repeat` *count* `read`

`macro` *othermacrofile*

`repeat` *count* `macro` *othermacrofile*

and accumulates the sum over the products. If the `itime` argument is zero, it is replaced by (an estimate of) 1.3 seconds.

5.4.4 Macro Generators

Lengthy macros can essentially be created by any other high level language with loop control. We provide some examples based on languages that are available on Unices.

Shell Here is an example of a bash-shell executable with a double loop which generates 18 read-save cycles—three different values of the `ems` parameter and six different subframe coordinates. The bash-script would be put in a file like `tst.sh`, and generate the macro with `chmod +x tst.sh; tst.sh > tst.mac`:

```
#!/bin/bash
for e in 1 2 4 ; do
    echo "roe" ems $e ;
    for w in 0 1 2 3 4 5 ; do
        echo "subwin auto 1 " $(( w * 128)) $((w * 128)) 128 128 ;
        echo "read" ;
        echo "sync" ;
        echo "save -i -f 2" ;
        echo "subwin clear" ;
    done ;
done
```

awk Another example of a double loop put into a file `tst.awk` and then generating a macro calling awk as `awk -F tst.awk > tst.mac`:

```
BEGIN {
    emsarr[1] = 1 ;
    emsarr[2] = 2 ;
    emsarr[3] = 4 ;
    wxy[1] = 0 ;
    wxy[2] = 2;
    wxy[3] = 3;
    wxy[4] = 4;
    wxy[5] = 5 ;
    for (e in emsarr ) {
        printf("roe ems %d\n",emsarr[e]) ;
        for ( w in wxy ) {
            printf("subwin auto 1 %d %d 128 128\n", wxy[w]*128,wxy[w]*128) ;
            printf("read\n sync\n save -i -f 2\n subwin clear\n") ;
            }
    }
}
```

m4 A third variant is to save some typing by expansion of m4 macros. If a file `tst.m4` contains

```
#define a m4 macro expo with a roe-subwin-read-sync-save-sync atomic operation
define(expo,
# interpret the first argument as an ems paramter
roe ems $1
# interpret the second and third parameter as the lower left coordinates
# of a window divided by 128
subwin `auto 1 eval('$2` * 128) eval('$3 `* 128) 128 128'
read
sync
save
sync
subwin clear
)
```

```
# run one exposure with ems=1, then one with ems=2 and another with ems=1
expo(1,1,1)
expo(2,2,2)
expo(1,3,4)
```

then `m4 mloop.m4 > tst.mac` generates a file with three exposures.

The same "macro generator" variants could be worked out in many other programming languages.

Driver Loops An alternative is to drive the instrument through the `cmd_`*extension* interfaces of the `scripts` directory (here: `cmd_carmenes` or `cmd_carmenes_new` for example) from other programs/interpreters (bash, perl, python, tcl, MIDAS,...). Macros are not needed in such case.

A python script would do this by its `os.system` calls. An example with three outer loops over a variable `e` which feeds the `ems` setting and five inner loops over a variable `w` which implements a marching square subwindow might look as follows:

```
import os;
for e in [1,2,4]:
    os.system('cmd_nirva_new roe ems '+str(e))
    for w in [1,2,3,4,5]:
        os.system('cmd_nirva_new subwin SW 1 ' + str(w*128) + ' ' + str(w*128) + ' 128 128' )
        os.system('cmd_nirva_new subwin on auto' )
        os.system('cmd_nirva_new read' )
        os.system('cmd_nirva_new sync' )
        os.system('cmd_nirva_new save -i' )
        os.system('cmd_nirva_new sync' )
        os.system('cmd_nirva_new subwin clear' )
        os.system('cmd_nirva_new subwin off' )
```

In the more familiar bash shell an example might look like

```
#!/bin/bash

for (( j = 1 ; $j <= 10 ; j++ )) ; do
    echo starting exposure $j ;
    snd_panic_new read ;
    snd_panic_new sync ;
    snd_panic_new save ;
    sleep 10 ;
    snd_panic_new sync ;
    echo done exposure $j ;
done
```

5.5 Shell Commands

After installation of the manual pages (Section 2.6.2), the following documents of programs in the Linux shell are available by calling man(1), of which we show the first pages:

NAME

GENERIC − GEIRS startup script

SYNOPSIS

start_nirva_new [-iwin] [-gui] [-disp] [-cmd]

start_nirva [-iwin] [-gui] [-disp] [-cmd]

start_nirva_old [-iwin] [-gui] [-disp] [-cmd]

start_luci2_new [-iwin] [-gui] [-disp] [-cmd]

start_luci2 [-iwin] [-gui] [-disp] [-cmd]

start_luci2_old [-iwin] [-gui] [-disp] [-cmd]

start_luci1_new [-iwin] [-gui] [-disp] [-cmd]

start_luci1 [-iwin] [-gui] [-disp] [-cmd]

start_luci1_old [-iwin] [-gui] [-disp] [-cmd]

start_panic_new [-iwin] [-gui] [-disp] [-cmd]

start_panic [-iwin] [-gui] [-disp] [-cmd]

start_panic_old [-iwin] [-gui] [-disp] [-cmd]

start_carmenes_new [-iwin] [-gui] [-disp] [-cmd]

start_carmenes [-iwin] [-gui] [-disp] [-cmd]

start_carmenes_old [-iwin] [-gui] [-disp] [-cmd]

start_sc_new [-iwin] [-gui] [-disp] [-cmd]

start_sc [-iwin] [-gui] [-disp] [-cmd]

start_sc_old [-iwin] [-gui] [-disp] [-cmd]

OPTIONS

-iwin Opens the auxiliary intialization window

-gui Opens the controls GUI

-disp Opens the GUI with the real-time image display of the pixels

-cmd Starts the command server

If the commands are used without option, all four options are activated.

DESCRIPTION

Starts GEIRS for either LINC-NIRVANA, LUCI1, LUCI2, PANIC or CARMENES. If 3 or more GEIRS versions are installed in the GEIRS directory, the command versions with the *_new* start the GEIRS version with the highest revision number, the command versions with the *_old* start 3rd newest version, and the command versions without such *_new* or *_old* name component the 2nd newest version.

The script sets the most important environment variables and moves on to the initialization GUI.

The script does not start GEIRS if the standard TCP socket for the instrument is already in use or if the user is already running GEIRS.

The option -gui does not work if the interface to the detector has not yet been initialized.

SEE ALSO

geirs_cleanup(1)

NAME

TwoMassCnvrt − extract positions and magnitude from 2MASS in skymaker format

SYNOPSIS

TwoMassCnvrt [-D *2massdir*] [-r *RA/h*] [-d *DEC/deg*] [-p *px*] [-s *arcs*] [-m *mag*] [-b {J,H,K}] > *sky.list* 2> *sky.hdr*

OPTIONS

-D is followed by the location of the directory of the 2MASS catalog. This is without the ???/t*.cat portion of the file names.

-r is followed by the right ascension (in hours from 0 to 24) of the pointing in the center of the FITS plate. Instead of a floating point number in hours, the RA may also be provided by the standard two-colon hex-format, HH:MM:SS.ss.

-d is followed by the declination (in degrees from -90 to 90) of the pointing in the center of the FITS plate. Instead of a floating point number in hours, the DEC may also be provided by the standard two-colon hex-format, +-DD:MM:SS.ss.

-p defines the number of the pixels along x and along y. (We are only dealing with quadratic detector areas.) The product of this with the pixel scale is the two-sided field of view in which stars of the 2MASS catalogue must reside to be copied to the output. Warning: this *must* be the same as the IMAGE_SIZE in the sky.conf file .

-s is the pixel scale in units of arcseconds per pixel. Warning: this *must* be the same as the PIXEL_SIZE in the sky.conf file .

-m clips the magnitude (in the infrared band, not referring to the visible) of the star list that is put to the output. A number of 8.5, for example, means that only objects brighter than 8.5 (numerically smaller than 8.5) are copied over.

-b is followed by a single capital letter, one out of three J, H or K as expected.

-q is followed by a number between 0 and 1, which scales the magnitude of the star in the output according to that quantum efficiency.

-G generates a start catalogue as used with the display of the GEIRS detector software of the MPIA. If that selection of the output format is made, the value of the -q-option is ignored.

DESCRIPTION

TwoMassCnvrt extracts star positions and magnitudes from the 2MASS catalogue (on the user's file system) and generates an ASCII format of the stars distributed over the pixels in the field of view in the catalogue style of skymaker.

The prerequisites of running the program are the regions of interest of the 2MASS catalog in the standard layout in the file system, which are files named ../???/t*.cat, where the three question marks are the three digits of the quantized declination (measured from 0 of the southern pole up to 179).

This means the program will scan these directories, and if some of the files or their lines are missing, the stars that are not found will not be produced by the program either.

The standard output contains lines in the Skymaker format, a 100 followed by the two FITS pixel locations and a magnitude. The standard error contains a snapshot that would be added to the FITS file header of what will be produced by Skymaker to have a useful WCS system across the FITS image.

EXAMPLE

Additional portions of the FITS header go to sky.hdr for later inclusion by an external program.

TwoMassCnvrt -D ../../2mass/tmc1 -d 0.160960 -r 18.47378813 -b K -p 2048 -s 0.45 > sky.List 2> sky.hdr

Assume that sky.conf takes sky.fits as the name of the output file and that this is made explicit in sky.conf . This run generates sky.list. Fedithead then inserts the keywords of sky.hdr.

sky sky.List

NAME

ds9loop − call ds9 in a loop over FITS files in directories

SYNOPSIS

ds9loop [*ds9option* ...] *directory* [*directory* ...]

DESCRIPTION

The command interprets all arguments that start with a dash as ds9(1) options, and all others as directories. It calls ds9(1) with the options sequencing through all files with suffix .fits .

The user must close (or exit) the ds9 GUI to move on to the next FITS file.

EXAMPLES

ds9loop .

ds9loop /data1/Panic

ds9loop -multiframe .

ds9loop -mosaicimage /disk-d/carmenes/DATA/2015-02*

NAME

fedithead − batch FITS primary header keyword editor

SYNOPSIS

fedithead [-v] *fitsfilename templatehdrfilename* [*templatehdrfilename* ...]

OPTIONS

An optional argument `-v` triggers a detailed message of the program for each keyword changed.

DESCRIPTION

Fedithead edits FITS header data following directions from a configuration file.

The first command line argument is the file name of an existing FITS file which is to be modified, i.e., rewritten on return.

The second argument and optionally further arguments are ASCII files structured very similar to the template files used with http://heasarc.gsfc.nasa.gov/fitsio/fitsio.html/ and https://heasarc.gsfc.nasa.gov/ftools/caldb/help/fmodhead.txt/.

TEMPLATE FILE SYNTAX

Each of these may contain empty lines and comment lines (starting with #) that have no effect.

It may contain lines starting with the dash (-) that demand removal of the keyword from the FITS header. (If that keyword does not exist this does not have any effect.) The keyword may have regex expressions to deal with a group of keywords at once.

It man contain lines that embed two keyword names between colons (:) or between exclamation marks (!), so there are three of these delimiters in that type of line. (This is a syntactical extension to template files of fmodhead, fthedit and the cfitsio templates). Fits header cards with names matching the regular expression delimited by the first two colons have their names substituted by the substitutional expression between the 2nd and third colon. (Values and comments remain as they are).

It may contain lines that start with at least 8 blanks. The rest of these lines is turned into COMMENT lines that are appended to the FITS header.

Finally, all other lines are interpreted as keyword-value-comment triples in FITS header style (with = and / as delimiters), that trigger adding that card to the header. (Existing keywords with the same name are removed).

EXAMPLE TEMPLATE FILE

```
# delete CHOP_A and CHOP_B
-CHOP_[AB]
# replace RHUM by a hierarchical version
:RHUM:HIERARCH LN AMBI RHUM:
# rename enumerated wheels to filters
:WHEEL(\1):HIERARCH LN ICS FILT\1:
# add a OBSERVAT keyword
OBSERVAT = "LBT" / on the mountain
# add a comment
     Nice observation conditions. Dry with occasional snowflakes.
```

SEE ALSO

fthedit(1) fmodhead(1)

NAME

fitsImg2Asc − convert primary HDU of a FITS file to ASCII

SYNOPSIS

fitsImg2Asc *fitsIn.fits* > *fitsout.plt*

fitsImg2Asc -r [*xstrt*:*xend*,*ystrt*:*yend*] *fitsIn.fits* > *fitsout.plt*

fitsImg2Asc -h [-d] [-l] [-N *bins*] [-m *minvalue*] [-M *maxvalue*] [-a [*xmin*:*xmax*,*ymin*:*ymax*]] [-t *out.txt*] [-o *out.eps*] *fitsIn.fits* [*fitsIn.fits* ...]

fitsImg2Asc -b [-i] [-a [*xmin*:*xmax*,*ymin*:*ymax*]] -m *minvalue* -M *maxvalue* [-X] [-Y] *fitsIn.fits fitsOut.fits*

DESCRIPTION

The program fitsImg2Asc converts the image in the primary HDU of a FITS file to an ASCII format. The input file is an image in the FITS file, of which only the first slice is taken if this is a FITS cube.

3D view

The standard syntax is

```
fitsImg2Asc fitsIn.fits > fitsout.plt
```

or

```
fitsImg2Asc -r '[xstrt:xend,ystrt:yend]' fitsIn.fits > fitsout.plt
```

which means that the command line argument is the name of the FITS file with the image, and the output is redirected into some other file. This output file will be roughly a factor of 4 larger than the input file, and the program will run slowlier than some people would expect. In almost all cases the field will be too crowded to get useful response times from gnuplot while rotating the image, so the option -r allows to take only a rectangular subarea of the image, where the 4 arguments are 0-based ranges for the two pixel axes (different from the FITS convention).

The output contains lines with three values, which is the x coordinate of the pixel, the y coordinate of the pixel, and the value in the image at this pixel.

This ASCII file has been targeted for use with a gnuplot(1) session e.g. like:

gnuplot

gnuplot> set xlabel 'x pixel'

gnuplot> set ylabel 'y pixel'

gnuplot> set zlabel 'adu'

gnuplot> splot '....' wi li # insert the fitsout.plt file data name here

gnuplot> set grid

gnuplot> set contour base

gnuplot> replot

gnuplot> set logscale z

gnuplot> replot

Example: `fitsImg2Asc -r '[200:800,1200:1800]' fitsIn.fits > fitsout.plt`

Histogram

The syntax to generate a gnuplot X11 window or EPS file with a histogram of pixel ADU values is triggered by the -h option as follows:

```
fitsImg2Asc -h [-d] [-l] [-N bins] [-m min] [-M max] [-a
[xmin:xmax,ymin:ymax]] [-o fitsout.eps] fitsIn.fits [fitsIn.fits ... ]
```

The option -N followed by a positive integer number can be used to specify the number of bins to be generated. If not provided, the program uses a default.

The option -m followed by a number is the minimum number on the horizontal axis which delimits the

NAME

fitsort − list selected FITS header values from a set of FITS files

SYNOPSIS

dfits ... | fitsort [-d] *KEY1* [*KEY2* ...]

OPTIONS

-d means that fitsort does not print the header line with the FITS keywords.

DESCRIPTION

The standard input of fitsort must be the output of the dfits(1) command. The program prints a spreadsheet table with tab-separated columns which shows for each of the FITS files (row by row) lines with the values of the specified keywords listed side-by-side.

This answers quickly a question like *what have been the integration times for the exposures in the FITS files* ?

EXAMPLES

dfits *.fits | fitsort ITIME RA

NAME

geirs_cleanup − remove residual GEIRS components left over by a previous run

SYNOPSIS

geirs_cleanup [-v] [t] [-a] [-p *catmpdir*]

OPTIONS

-v leads to more verbose output of the actions

-t tests whether any actions would be taken, without actually executing them. This is a dry run.

-a Removes also temporary files. The set of files that are concerned are the files that store parameters like save paths, IP addresses, telescopes and so on that are saved at shutdown time to re-appear in the next startup GUI.

-p Allows to specify the path name of the temporary files. The default is the caller's $CAMTMP, $TMPDIR, $TMP and then ˜/tmp directory. This option is usually needed if the CAMTMP environment variable defined in the startup script is not defined in the caller's shell, but TMPDIR and/or TMP are defined and differ from CAMTMP.

DESCRIPTION

The script shuts down a GEIRS run by sending signals to the four components (the two GUI's, the command manager and the shared memory manager) and removing the shared memory blocks and shared memory socket.

It is used within the GENERIC script to test whether GEIRS is already running for this or another user.

The script is an emergency script to be used in case a previous GEIRS run was shut down inappropriately (for example caused by power outages) or another user is running GEIRS under the same account and left the GUI's in some unreachable state.

ENVIRONMENT VARIABLES

The variable CAMTMP (with a default backup of $HOME/tmp) is used to locate the shared memory socket to be removed.

EXAMPLES

geirs_cleanup -v -t

NAME

geirs_Cmd − send a GEIRS command to a GEIRS command server

SYNOPSIS

EXAMPLES

NAME

geirs_control − open the GEIRS control GUI

SYNOPSIS

geirs_control [-x xdevice] [-d xdevice] [-f font] [-r] [-t]

OPTIONS

-x or -d followed by a X11 device name specify on which display the GUI is opened.

-f followed by an X11 font name specifies the font to be used for labels and fields.

-r disables the motor wheel submenus. This is useful for the cases where GEIRS does not control motors, which means for LUCI, CARMENES and Linc-Nirvana.

-t disables temperature monitor functionality. This is useful where GEIRS does deal with temperatures and pressures, which means for LUCI, CARMENES and Linc-Nirvana.

DESCRIPTION

The control GUI is usually either started by default when GEIRS is started or sometimes not started at all if any client takes full control of the exposures. This means the *geirs_control* command is mainly useful to operators who have closed the GUI with the X-button of the window manager and want to get it back.

Colors

The buttons, submenues and input fields (that is, the 'active' components) are light grey. The parameters computed by the software ('passive', output only) are dark grey.

The disk fill status shows in red the portion of the CAMPATH that is already full, in green the available free space. This is equivalent to df(1) for the partition shown in the file CAMPATH usually located in $HOME/tmp .

Options submenu

Allows to specify the directories that contain

- the *Save path* where the FITS files or raw dumps will end up,
- *Macro path* where the software will search for macro files,
- *Object path* where the software will search for the ASCII files with star catalogues (relevant for the file name of the catalog that goes into the *Object-List* of the telescope GUI). Some fine control of the files with the sounds (volume, on/off) is avialable in the *Sounds* submenu.

NAME

geirs_dropcaches − drop the file system and memory caches kept in memory

SYNOPSIS

geirs_dropcaches [-m *MiB*]

OPTIONS

-m The threshold that triggers executing the dropping in units of MiB. If not used, the default is 8192.

DESCRIPTION

The program executes effectively a 'sync; echo 3 > /proc/sys/vm/drop_caches' when the free amount of memory drops below the threshold (which lets the Linux OS clear the current caches in the virtual memory).

This is called by GEIRS at the start of every read that involves the PLX driver. The default threshold of 8192 used within GEIRS can be changed using the put command of the GEIRS interpreter while GEIRS is running, for example

put DROPCACHE 1024

to use 1024 MiB in the future. Note that all values defined by *put* are forgotten when GEIRS is shut down; so the effect of such a modification would only last for the current GEIRS session.

NAME

geirs_lamp.sh − status of the CAHA calibration lamp state for PANIC

SYNOPSIS

geirs_lamp.sh ALLOFF

geirs_lamp.sh L1 {ON | OFF}

geirs_lamp.sh L2 {ON | OFF}

geirs_lamp.sh L3 {ON | OFF}

geirs_lamp.sh L4 {ON | OFF}

geirs_lamp.sh L5 ON {1|2|3|4|5|...9}

geirs_lamp.sh L5 OFF

geirs_lamp.sh STATUS

DESCRIPTION

The command is called by using the **lamp** command in the GEIRS shell.

It executes a rflats command (for switching calibrations lamp on or off) followed by a rflats status command which

- leaves a FITS line at a standard place searched by GEIRS for add-on FITS lines, and
- echos a string suitable for storage in the GEIRS online data base.

Warning: there is no timeout currently implemented here. If the ssh hangs for any reason, this will cause an indefinite pausing of GEIRS (because there is no timeout currently enacted on the GEIRS side.)

This file has no use beyond GEIRS implementing PANIC at the Calar Alto.

ENVIRONMENT VARIABLES

The variable TELESCOPE determines which of the CAHA computers is consulted to execute the rflats command.

FILES

The output of the command is registered in $CAMTMP/geirsPhduAdd.panic_1 . If CAMTMP is not defined, it is replaced by $HOME/tmp .

EXAMPLES

geirs_lamp.sh L5 ON 4

NAME

geirs_quitXterm.sh − close open auxiliary GEIRS xterm windows with log monitors

SYNOPSIS

geirs_quitXterm.sh

OPTIONS

none

DESCRIPTION

The command closes the auxiliary x-terminals that show aspects of the GEIRS logging. These might have been opened by selecting some of the monitors of the controls GUI.

The script is called for example when a quit command is received by the GEIRS command (shell) interpreter.

EXIT VALUE

Always 0 (success)

NAME

geirs_roeDump.pl − dump the current contents of the ROE FPGA to standard output

SYNOPSIS

geirs_roeDump.pl *instrument*

OPTIONS

instrument is the mandatory argument which is a string like Luci1, Luci2, Panic, Carmenes or Nirvana . It is case-sensitive.

DESCRIPTION

The command is a debugging aid for ROE pattern developers in the devel subdirectory of the source code. It prints the most recent contents of the entries downloaded to the ROE to standard output.

It does this by filtering the ROE log file for commands of the 7xx and 5xx family, not by actually reading the content of some online ROE. Therefore the command can also be used if the ROE is run in simulation.

Note that the script is not generally placed into the scripts directory of CAMHOME; therefore using a full path name or changing into the devel subdirectory is required to call it.

ENVIRONMENT VARIABLES

The variable CAMHOME must point to the top directory of the installation. The log file to be scanned is in $CAMHOME/log/ .

EXIT VALUE

Always 0 (success)

EXAMPLES

geirs_roeDump Luci1

geirs_roeDump Luci2

geirs_roeDump Panic

geirs_roeDump Nirvana

geirs_roeDump Carmenes

NAME

geirs_srreConfig − configure the srre mode's reset windows of upcoming GEIRS reads

SYNOPSIS

geirs_srreConfig -i *configfile* -p *infodirectory*

geirs_srreConfig -p *infodirectory*

geirs_srreConfig -f *fitsfile.fits* [-N *wincnt*] [-w *width*] [-h *height*] [-v] [[-r] -o *fitsofile*]

OPTIONS

-v leads to more verbose output of the actions

-p defines the name of the INFO sub-directory with the patterns

-i defines the name of the text file with the quasi-FITS syntax that provides the window coordinates

-f defines the name of an existing FITS file with an image in the primary header

-N defines the number of reset windows to be created

-w defines the width of each reset window in units of pixels

-h defines the height of each reset window in units of pixels

-o defines the (not yet existing) FITS output file name which will contain a copy of the input file, but pixels in reset windows set to zero.

DESCRIPTION

See the GEIRS user manual.

In the first syntax, the existing configfile is read and updates the files in the pattern directory that concern the srre reset window placement.

In the second syntax, the current reset windows in the pattern directory are dumped to standard output.

In the third syntax, the input FITS file is scanned for bright regions, which are used to define the places of the reset windows. This proposal of reset windows is written in configuration file format to the standard output.

EXAMPLES

5.6 Windows

5.6.1 Window Classifications and Nomenclature

GEIRS uses three basic types of windowing for a variety of different purposes:

1. Sets of sub-areas of the full frame detector images which are read from the detector and saved to the FITS files. The geometry is configured by the `subwin` commands to the command interpreter (Section 5.3). The underlying actions are that only sub-areas of the detector are read out, followed by some clipping of the resulting information by the GEIRS software. (What is created by the detector and readout hardware is called hardware windows and what is in left by the further reduction within GEIRS called software windows.) *This is what is usually meant by an infrared astronomer talking about subwindows!* This appears to be implausible: instruments with bigger and bigger cameras are assembled, why would one discard some of the information in the images? The dominant reasons are that (i) one can increase the frequency of image generation (Section 8.6), if the object quivers on some fast time scales, or (ii) reduce the disk space consumption of the FITS data by discarding flat field empty areas of the detector that are of no interest.

   In summary, there is *no* scenario where using this type of subwindows makes sense for CARMENES, so the `subwin` command should be ignored:

   - The information of the dispersed spectra and the modes is well distributed over both detectors, and the traces of the spectra are curved. There are no vast rectangular non-illuminated windows left that could be used as subwindows.
   - There is no need to achieve integration times smaller than the standard 2.7 seconds of a full-frame read; for this fiber-fed spectrosopic instrument integration times are fundamentally longer.

2. Resetting some areas of the frames after each `read` while the (otherwise non-destructive) reads of multi-correlated readout modes are ongoing. This is only supported by Hawaii-2 RG detectors in conjunction with some of the MPIA ROE's (i.e., those of LUCI and CARMENES but not of PANIC) and will be called the subwindow reset mode. The interface shows two aspects: First telling GEIRS where these windows are located in the FITS coordinate system in the detector plane, second telling GEIRS that the subsequent detector readouts should use the mode (command `ctype srre`, Section 5.6.2). In a vague sense this results in some opposite of the windows in the first item: the selected areas remain dark(er) than the rest of the images, whereas in the bullet above only the areas inside the windows remain visible.

   The main objective of this mode is to subdue brightly illuminated parts on the detector. One can increase the integration time such that the readout values of most of the pixels increases, and at the same time the pixels in the reset windows are often reset and do not saturate as they would otherwise. Overall this helps to increase the accessible contrast, and is typically used for spectroscopic modes (read: LUCI and CARMENES) with a small number of bright lines that can be sacrificed for the benefit of the others.

3. Saving some areas of the frames into files while the non-destructive reads of multi-correlated readout modes are ongoing. This is some internal "software trigger" feature build into GEIRS and shall be called the guide mode. This is configured with the `sfdump` command (Section 6.5).

   GEIRS started for CARMENES uses this to create snapshots of each read during the multi-correlated non-destrucive reads in preparation of its pipeline step that reduced these frames to a single image.

The general setup is that any mix of these three window clipping features with three different sets of windows is active/enabled.

5.6.2 srre Readout Mode

Section 5.6.2 is of no relevance to PANIC or LINC-NIRVANA because either the detector or the ROE does not support this.

Principle of Operation On some MPIA readout electronics that control Hawaii2-RG detectors [13]— that is actually only CARMENES and LUCI now—the `srre` readout mode has been introduced. It is characterized by reading frames of the detector "non-destructively" while the detector is integrating, and resetting some of the pixels after each of these reads. This readout mode is activated with the `ctype srre` command (Section 5.3) and has the same global behaviour as the `srr` timing. The parameter of the `ctype srre` has the same meaning as for the `srr`; it is the number of reads and therefore also the number of resets distributed over the integration time at the end of the "ramp." If the integration time is 120 seconds, and the command is `ctype srre 7`, for example, every 20 seconds a frame is read and every 20 seconds the pixels inside the reset windows are reset.[15]

The difference between the `srr` and the `srre` (with resets) is that after each readout a finite subset of the pixels (called reset windows here) on the detector is reset. Consequences of this extended mode are that

- these reset windows never accumulate more light than equivalent to the time between two readouts, whereas the other pixels have much longer integration times that linearly rise from frame to frame. This points at the principal application of the mode: protection against pixel saturation, plus the standard advantages of less cross-talk and less memory effects between exposures.
- in the standard linear fit of ADC value as a function of frame number through the samples within GEIRS that combine all the frame samples to a single image when calling `save`, the brightness of pixels inside the rectangles of the reset windows is essentially zero (because this is the slope through a time series of pixels that appear in each frame with approximately the same ADC values). An equivalent set of rather dark rectangular shapes of the reset windows is also visible if the frames are saved individually with `save -S...` or online with the `sfdump` configuration.
- The (minimum) integration time of the exposure increases roughly linear to the number of reset windows, needed for downloading and executing the resets sequentially. This prolongation is negligible in practise.

Reads Parameter The number of samples along the "ramp" is an integer $N \geq 2$ and a free parameter which is to be specified by the operator with the `ctype` command. There are some technical constraints, however, which set limits on N, and some interrelations with other parameters of the exposure:

- With the standard full-frame readout and at the standard pixel time of 10 μs (command `ptime`), reading once the detectors in the `srr(e)` modes needs slightly less than 1.4 seconds,

[15]Note the simple arithmetics: $N = 7$ reads corresonds to $N - 1 = 6$ intervals.

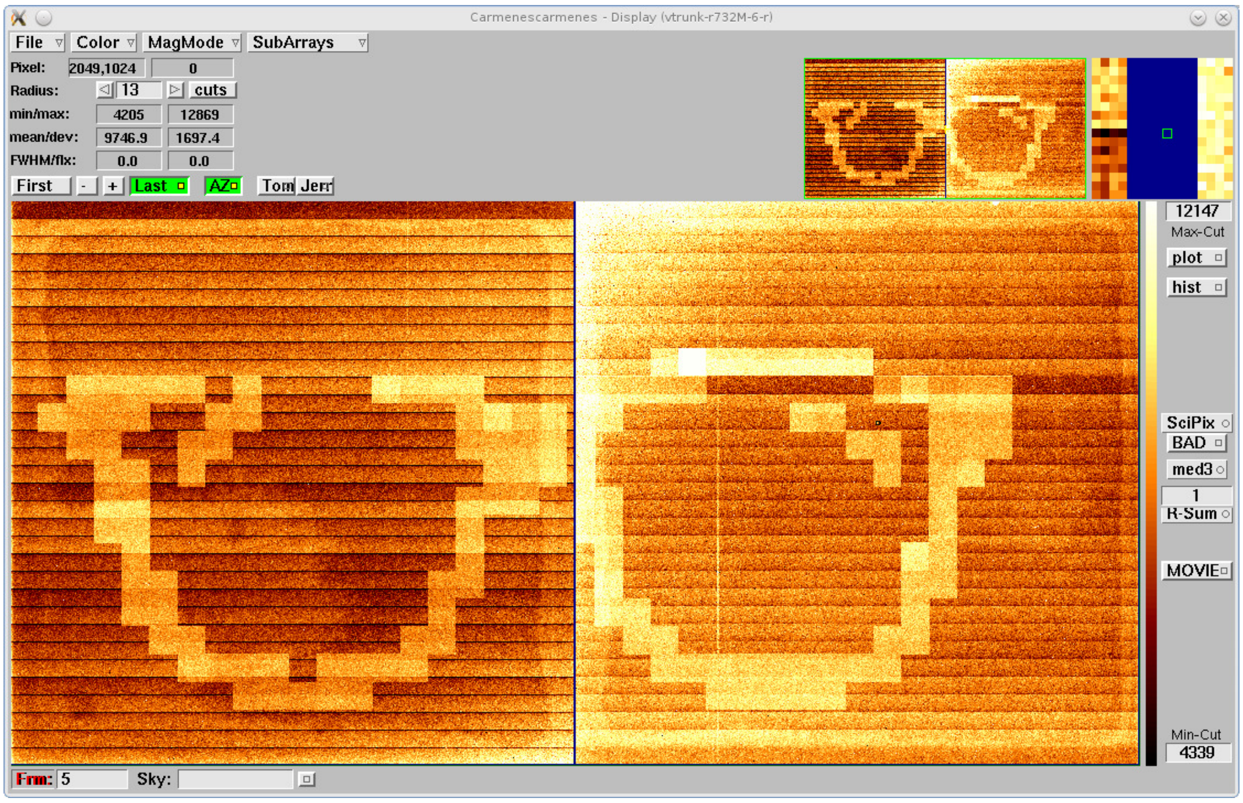


Figure 30: Example of a CARMENES exposure with 74 reset windows on the left and 68 reset windows on the right detector chip, each 102×102 pixels. This is the fifth frame in a ramp of five.

a hard limit to the full-frame sampling frequency. Supposed the integration time I as specified with the `itime` command (Section 5.3) is set from the usual considerations on fluxes, readout-noise and so on, this trivially leads to

$$N - 1 \le I/(1.4\mathrm{s}). \tag{2}$$

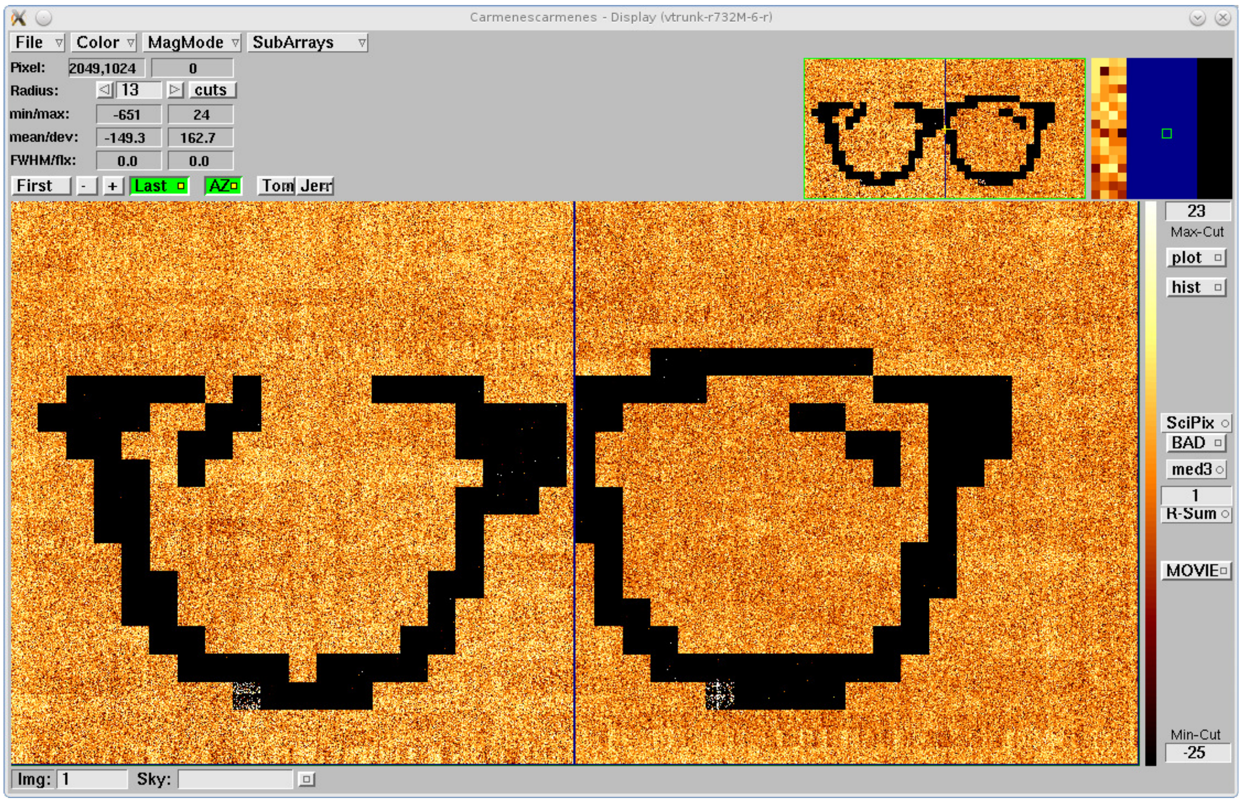
A maximum of I in spectroscopic modes is defined by the allowable shift of the radial velocity (i.e., line wandering on the detector) due to Earth rotation-nutation, due to Earth ecliptic motion, changes in air mass and so on while integrating.

- The parameter N defines the number of frames that will be stored on the workstation which runs GEIRS. There is a finite amount of RAM R and an alternating buffer scheme in GEIRS which leads to a maximum amount of available memory of $R/2$ for a single exposure started with the `read`. [In fact this is set with the `CAMSHMSZ` parameter at startup (Section 3.2).] Let $N_d = 1$ or $N_d = 2$ be the number of chips in the camera for LUCI or CARMENES, respectively. Each frame demands $2 \times N_d \times 2048^2$ bytes in memory, and the obvious constraint is

$$N \le \frac{R}{2 \times 2 \times N_d \times 2048^2}. \tag{3}$$

Note that this number needs in addition to be divided by the cycle repetition parameter (`crep` in Section 5.3), if exposures are scheduled to follow immediately on each other.[16] For the CARMENES workstation we have $R \approx 32$ GB, and each raw frame needs $2 \times 2 \times 2048^2$

[16]This is not relevant for the standard CARMENES operation because the `abort` command would terminate the entire sequence of exposures. So `crep` is almost always 1 here.



Pixel: 2049,1024 0
Radius: 13
min/max: -651 24
mean/dev: -149.3 162.7
FWHM/flx: 0.0 0.0
Max-Cut 23
R-Sum 1
Min-Cut -25
Img: 1
Sky:

Figure 31: The CARMENES image generated by the linear fit through 4 frames (see Section 5.6.2) associated with Figure 30.

B = 16 MB. So a maximum of $32,000/2/16 \approx 1,000$ frames can be stored

$$N \leq 1000. \tag{4}$$

- The fundamental idea of the `srre` mode is to clamp bright pixel regions. The parameter N defines not only the number of reads along the ramp; because the number of resets equals the number of reads, it also defines the number of resets along the ramp. Let I_s denote some estimated maximum integration time that can be tolerated for saturation and memory effects in the reset regions, then

$$N - 1 \geq I/I_s. \tag{5}$$

- Monitoring variations in flux, supposedly variable sky transmission due to cloud coverage, cosmics and so on proposes to set a maximum time difference between samples of the order of $T_c \approx 1$ minute. On that ground

$$N - 1 \geq I/T_c. \tag{6}$$

- The parameter N is implemented as some sort of delay between two scans of the ROE through the detector. From the point of view of the software on the workstation it leads to an arrival of N frames (less if `aborted`) at regular time intervals $I/(N-1)$ during the ramp. This gives a strict constraint on the FITS data files that can be created, because data that did not arrive on the workstation cannot be `saved`. There is an explicit and an implicit method of saving the frames (which means, generating FITS files):

  – The command `save` generates a single FITS file by calculating a least squares linear fit through (almost) all N frames of each pixel. The command has a parameter `-S` which

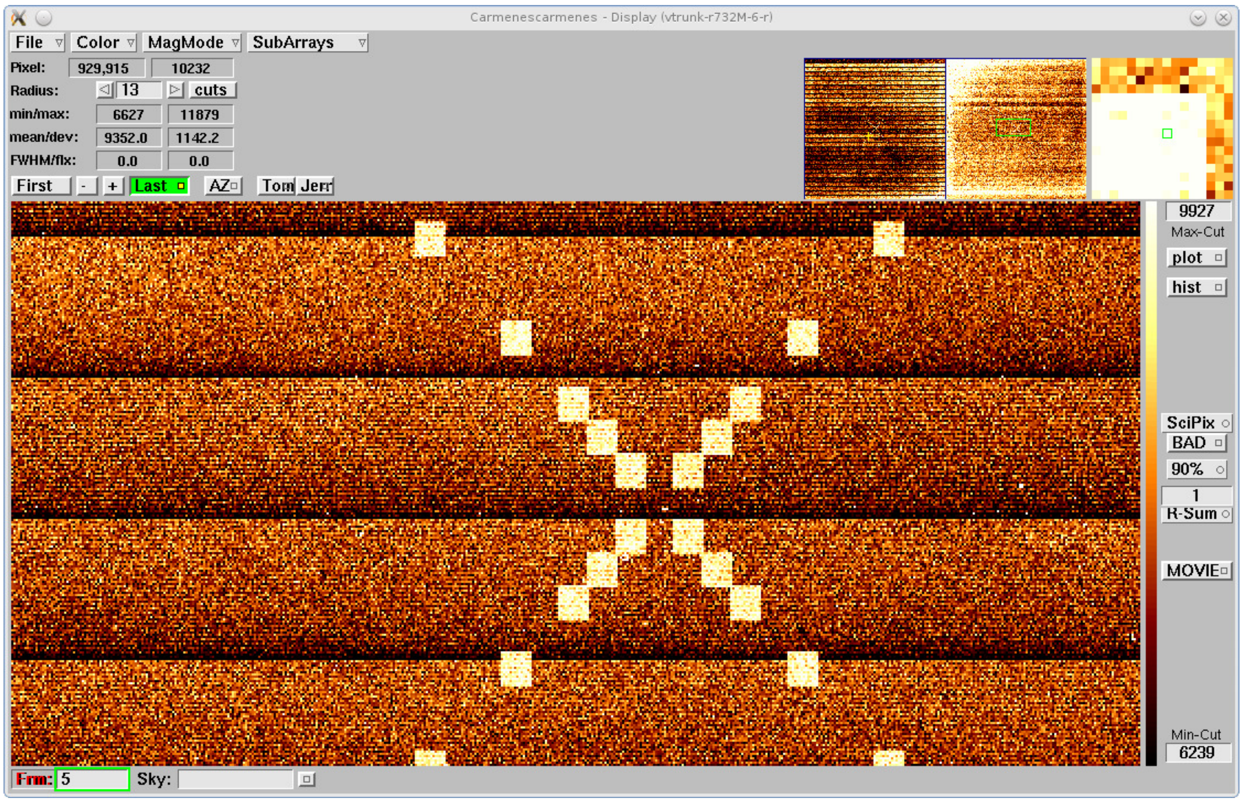


Figure 32: Zoomed view of an example of a CARMENES exposure with 14 × 16 reset windows on the right detector chip, This is the fifth frame in a ramp of five.

allows also to save individually each of the N raw frames, and the command may be repeated to generate both, the “correlated” image and the set of raw frames (Section 5.3.) Note that the parameter N impacts both (i) the time that is needed for the `save` due to calculating the fits, and (ii) the disk space that is required for the `save -S`. If one would save for example all CARMENES raw frames obtained at the minimum period of the aforementioned 1.4 s, equivalent to a data rate of 16 MB /1.4 s≈ 11 MB/s, the CARMENES disk space of 180 GB would be exhausted after $180,000/11$ s $\approx 16,000$ s $\approx$ 4.5 hours.

Note that the command `save` has a functionality to trigger any type of pipeline code that may deal with the FITS files (*not* the raw frames!) in more detail than just fitting a straight line through the time. [With the current GEIRS code this “hook” is already used to trigger deletion of old FITS files in the data directory such that at least 10% of free disk space remain on the associated partition of the NIR workstation. It is also used to start the First Stage Pipeline [14].]

– Because saving the probably large number of “fast” N frames is usally not needed and has some disadvantages detailed above, there is an online GEIRS mechanism (command `sfdump` in Section 5.3 and Section 6.5) which stores the frames on disk while the exposure continues. These are the raw frames available to the pipeline [14]. The configuration options explained in Section 6.5 allow to subsample the raw frames, i.e., to store only each second or each third etc. frame. This helps to avoid the time and disk space overhead mentioned above, but does not support irregular frame subset picks.

Figure 34 illustrates how the integration time and the parameter N fix a time $I/(N-1)$ between the raw frames that are stored in the computer’s RAM, and how a subset of these frames is dumped

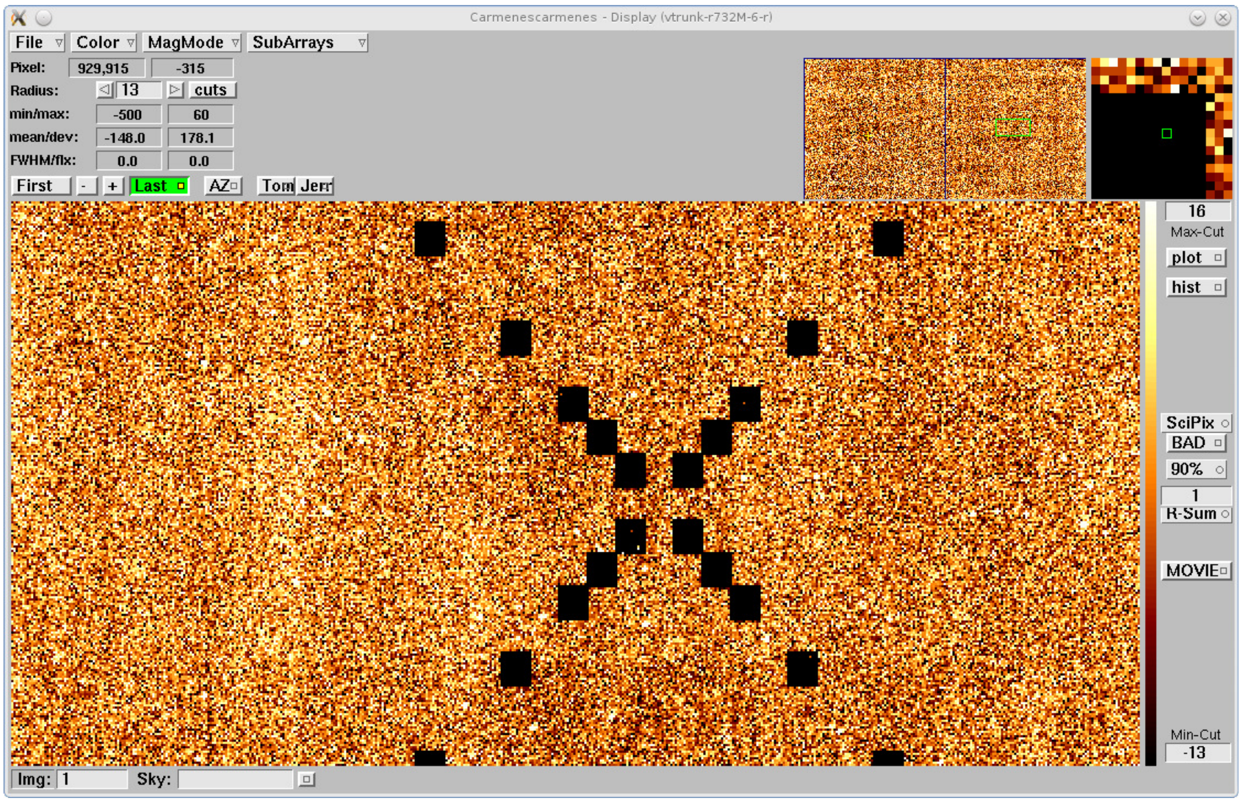


Figure 33: Image generated by the linear fit through 4 frames associated with the CARMENES Figure 32.

into FITS files for reduction by a pipeline [14] or online monitoring.

Correlated Image The construction of a correlated image from the set of the frames is the same for `srr` and `srre`: An optional number N_d of first frames out of the N frames that have been read is ignored/dropped. For each pixel the standard linear least squares fit is generated individually through the $N - N_d$ frames that have not been dropped. (Such a fit needs at least two points on the time axis to draw a line, because one cannot fit a line through a single point to get a slope. Accordingly, if the number of frames that would remain is $N - N_d < 2$, these frames are not actually dropped but used to define the fit.) The slope of that fit is multiplied by the number of time slots along the ramp, which is $N - 1$, to calculate the count equivalent to the full integration time along the ramp. This number is stored in the FITS file for that pixel.[17] (There is a small speciality for CARMENES: if the pixel is inside one of the `srre` windows, not that number derived from the fit's slope is stored in the FITS file but a zero. This serves as an indicator to any followup software that these regions inside the reset windows should not be interpreted as fits. The values in the online display, on the other hand, are not zeroed; the regions inside the reset windows of the glasses assembly in the GEIRS GUI in Figure 32, for example, are not entirely black, but some residual noisy speckles are still seen inside.)

The number of dropped frames is by default $N_d = 1$ with the current release of the software. It can be changed online with the `use` command; `use srr skip 0` for example would set $N_d = 0$ and hence incorporate all N frames in the fit for all subsequent exposures. `status use` shows the

[17] Actually the raw number is multiplied by N and the `BSCALE` keyword in the associated header is set to $1/N$ to compensate for that. This sort of adminstration improves the resolution of the integer data representation.

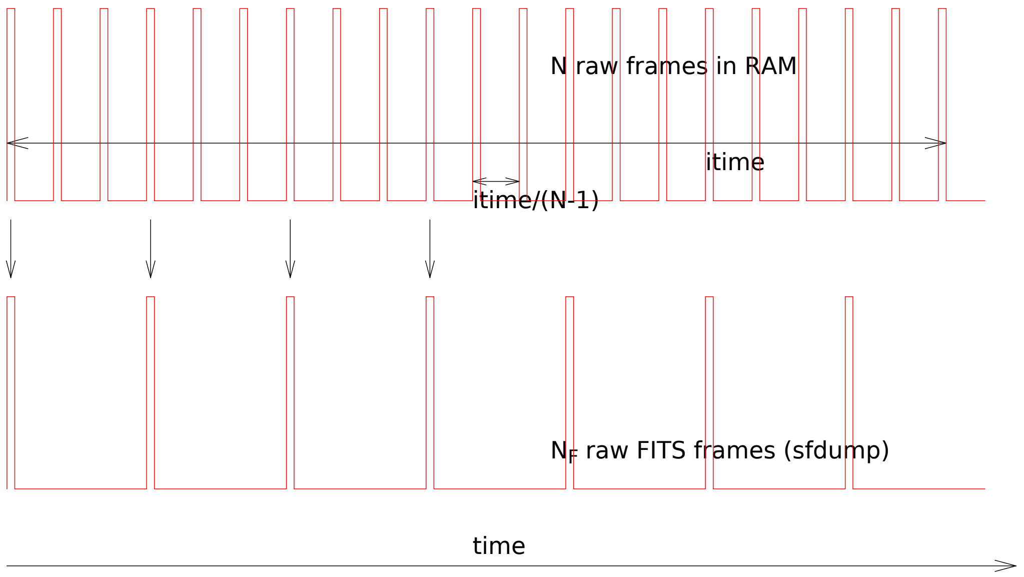


Figure 34: Upper plot: N raw frames at intervals $I/(N-1)$ in the computer's RAM. Lower plot: N_F FITS files generated from raw frames sub-sampled with `sfdump`, here with a sub-sampling factor of $s = 3$ in eq. (7).

current parameters for all readout modes. The choice to ignore the first frame (the frame just after the reset) to define the ramp is a matter of experience with the frames for most of the detectors at the current mix of idle and read modes. Broadly speaking the reset frame is often too bright, even brighter than the second frame, although it represents a state of essentially zero integration time: there is some sort of memory persisting through the line resets. Since the primary application of the `srr(e)` modes comes with long integration times and values of N typically of the order of tens, ignoring one "bad" out of the these frames is basically no loss integration efficiency.[18]

The raw 16-bit sequential frames are storing the pixels data as they are (no further interpretation or nulling). This gives a pipeline (smart enough to deal with the noise and the shifting effective integration time as discussed in Section 8.7) opportunity to extract line shape information even at these places within the reset windows.

Configuration The number of these reset windows is limited to 128 per chip, which is a limit resulting from the number of reserved registers in the RoCon firmware (not the H2-RG). There is in addition an effective maximum of the total number of reset windows (i) on both chips of CARMENES of currently 137, and (ii) on the single chip of LUCI of currently 83, which are limits set by some "line length" of 256 words in the RoCon firmware and in the layout of the patterns. The current maximum is therefore set to 63 per chip if the source code is compiled outside the MPIA, but will not be more than 128 in the future.

The configuration of the number and location of these reset windows is done with GEIRS by modifying the readout pattern files associated with the `srre` mode in the `$CAMINFO` subdirectory of the instrument currently in use. It is the operator's responsibility to

- define the pattern subdirectory that will be used. These are typically names like `Carmenes_-`

[18]We plan to drop the first pair for the Fowler-Type of interpretations somewhen in the future for the same reason.

r6, Luci2_r42 and so on combining an instrument name and svn revision number. Because the information of the directory name to be used is actually hidden inside the startup script, and this is not scanned easily, the current procedure demands explicit knowledge of that directory's name.

- fill an ASCII file with the srre configuration (windows and auxiliary parameters) prior to the next call of a read in srre mode if this is different from the previous exposure. The set of windows in this file replaces any previously defined set of windows; old windows are forgotten. GEIRS does not remember the previous setup; in practise only the headers of old FITS files reveal old window sets via the RESWN keywords (Section 6). In that sense the new file contains a *complete* set for the next exposures. (There is no interface for an incremental replacement, deletion or increment of individual windows.)
- transform that ASCII file to five associated pattern files in the aforementioned $CAMINFO directory with a call to geirs_srreConfig prior to calling the read. Note that the next read in the srre mode will then trigger an upload of a new pattern to the ROE and therefore need roughly 10 to 20 seconds (depending on network latencies, number of windows and so on) before the actual read process starts.

  Alternatively, one can append the configuration file name to the argument list of the ctype srre (after the number of reads) each time it has been changed. This generates the pattern files *and* loads them to the ROE.[19]

The configuration file looks like a FITS template file and contains lines of the following format:

- WIN[idx] = '[xstrt:xend,ystrt:yend]' A set of 1-based reset window specifications in the standard FITS syntax with ranges along the horizontal and vertical axis in the user's standard view of the images (i.e., including any optional modifications introduced by the CAM_DETROT90 and CAM_DETXYFLIP, Section 3.2). The upper limits of the number for xend and yend in the coordinates are multiples of 2048, depending on how many chips are in the detector, and for non-square configurations like CARMENES again depending on CAM_DETROT90 and CAM_DETXYFLIP. Ill-formatted specifications, like those where the quoation marks are missing or the xend is smaller than xstart or yend is smaller than ystrt, will be silently dropped.

  If a window stretches across more than one chip, it will only be recorded for the chip with the smaller x and y FITS coordinates—which in fact means that for CARMENES a window definition with xstrt $\leq$ 2048 and xend $\geq$ 2049 will define only a window on SCA2.

  Note that GEIRS will also reduce the windows to fit into the active 2040×2040 inner region of the chips; reset pixels covering the reference pixels are filtered by the software.
- DETROT90 = [integer] The same integer as used inside the startup script to initiate image rotations. If no such line exists in the configuration file, the default is taken from the shell environment variable CAM_DETROT90 of the user who calls geirs_srreConfig. If this is also not set, the default is 1 for CARMENES and 1 for LUCI.
- DETXYFLI = [integer] The same integer as used inside the startup script to initiate image rotations. If no such line exists in the configuratio file, the default is taken from the shell environment variable CAM_DETXYFLIP of the user who calls geirs_srreConfig. If this is also not set, the default is 2 for CARMENES and 1 for LUCI.

[19]This additional parameter makes possibly sense for LUCI where resolutions and masks are frequently changed. For CARMENES this is not supposed to happen because the window locations would change rarely, after earth-quakes or after exchange of the calibration sources.

- NDET = [integer] Number of chips in the detector. If such a line is missing, the default is 2 for CARMENES and 1 for LUCI. This keyword supports tests where the software is not run with the full number of boards or chips; for the same reason the `NDET` environment variable may be set in the startup script and selected in the GUI of Figure 4.
- COMMENT blabla Lines to be ignored and merely serving as comments to the configuration. There may be more than one of these comment lines.

All lines of these formats may be extended by a slash and further comments, which will be ignored by the parser build into `geirs_srreConfig`. Examples of these files with names like `srreMask*` are in the `GEIRS/`*version*`/test` subdirectory of the GEIRS distribution.

The format of this configuration file is the same as the format of the configuration file of the `sfdump` command to the GEIRS shell (Section 5.3). Both files contain (i) a set of rectangular window geometries in the full-frame coordinate system, (ii) a small set of other keyword-value pairs and (iii) comments. Because the `sfump` and the `geirs_srreConfig` parsers ignore keywords that are not on their individual parameter lists, one may use a single, merged common configuration file at both places *if* one whishes to reset a set of windows after each `srre` read *and* to dump exactly the same set of windows after each read for monitoring purposes.

`geirs_srreConfig` is an executable in the Linux binaries, not a command of the GEIRS shell (!). The syntax is

geirs_srreConfig -i *configfile* -p *infodir*

to translate an existing *configfile* to the five pattern files

1. *infodir*`/multi_win_res_coordinates.`*instru*,
2. *infodir*`/multi_win_res_init.`*instru*,
3. *infodir*`/multi_win_res_lay1.`*instru*,
4. *infodir*`/multi_win_res_lay2.`*instru*, and
5. *infodir*`/multi_win_res_pat.`*instru*

in the directory *infodir*. These five files are replaced/overwritten. *Never call this command before the current readout is finished and GEIRS has written the FITS files.* Caution: while GEIRS is running there is one active pattern subdirectory selected at startup time—by default the subdirectory with the highest version number (see `CAMROE_REV` in Section 3.2). If the *infodir* parameter provided here is different, you will see no effect on the window coordinates in subsequent readouts, because the pattern files have been updated in a directory which is not used by GEIRS.

There is a limit set to the number of window within the software to ignore windows that would not fit into some layers of the detector FPGA of the ROE. `geirs_srreConfig` ignores the abundant ones (i.e., drops those that are late in the file).

If *configfile* does not start with a slash, the full path name is `$CAMTMP/`*configfile* if the environment variable `$CAMTMP` is set, otherwise `$TMPDIR/`*configfile* and then `$TMP/`*configfile* if either `$TMPDIR` or `$TMP` are set, and eventually just *configfile* (praying that this makes sense relative to the current working directory of the caller).

If *infodir* does not start with a slash, the full path name is `$CAMINFO/`*infodir* if the environment variable `$CAMINFO` is set, otherwise `$CAMHOME/INFO/`*infodir* if `$CAMHOME` is set, then `$HOME/GEIRS/INFO/`*infodir* if `$HOME` is set, and eventually just *infodir* (praying that this makes sense relative to the current working directory of the caller).

The maintenance of the `srre` configuration is quasi static:

1. As seen above, the configuration *is* represented by an existing set of files in the (active) pattern directory in the computer's file system. As long as nobody changes these files by either calling `geirs_srreConfig` or running the `ctype srre` command with a file argument or switching to a different version of the pattern directory or editing the files by any other method, the places and size of the reset windows remain frozen. Starting with GEIRS version r748M-3, starting GEIRS overwrites the existing `srre` reset window set with a small default test case to improve recovery in case of attempts to leave the ROE FPGA in a partially configure state due to too large window sets. Any `read` with the `srre` mode uses the windows defined through these pattern files at that time.
2. The requirement to change these windows depends on (i) drifts in the optical setup of the instrument that may cause slow wandering of the spectral lines, (ii) on the necessity to subdue different line sets as a function of the different calibration lamps, (iii) modifications of the parameters for rotations and flips at GEIRS startup. All that is definitely not in the scope of the software manual.
3. The reset frequency is tight to the readout frequency and a consequence of the integration time and number of readouts of the ramp. Changing integration times or the number of readouts with the commands send to GEIRS does not require changing these pattern files.

Example From a driver's point of view, the scheme is

```
# create contents of srre.cfg by any means (shell, other programs,..., support routines)
echo "WIN1 = '[100:100,200:200]'" > $CAMTMP/srre.cfg
echo "WIN2 = '[700:710,200:200]'" >> $CAMTMP/srre.cfg
echo "DETROT90 = 2" >> $CAMTMP/srre.cfg
echo "DETXYFLI = 1" >> $CAMTMP/srre.cfg
...
```

and then use either

```
# update the pattern files in the pattern subdirectory
geirs_srreConfig -i $CAMTMP/srre.cfg -p $CAMINFO/Carmenes_r9
# start exposure in srre mode
snd_carmenes_new ctype srre 10
snd_carmenes_new read
snd_carmenes_new sync
snd_carmenes_new save
```

or

```
# configure and start exposure in srre mode
snd_carmenes_new ctype srre 10 $CAMTMP/srre.cfg
snd_carmenes_new read
snd_carmenes_new sync
snd_carmenes_new save
```

Support Routines

- There is also an option to extract the brightest regions from a FITS image with the syntax

  geirs_srreConfig -f *fitsfile* [-N wincnt] [-w width] [-h height] [-v] [[-r] -o *fitsofile*] > *configfile*

  that reads the FITS image in the file of the `-f` option, employs a set of windows each as many pixels wide and high as specified by the `-w` and `-h` options, and extracts the brightest regions by a count delimited by the `-N` option, and dumps the coordinates of these windows to the standard output. The option `-v` increases verbosity and lets the program report also the average ADU's in the computed subwidows. If the options `width` and `height` are missing, they default to 20. If one of the two width or height options is present and the other absent, the missing value will be set to the existing, resulting in square windows. If the option `-N` is missing, a default of 10 is substituted.

  The option `-o` followed by the name of a FITS file (which must not yet exist) creates the *fitsofile* with a copy of the image in *fitsfile*, but with the regions of the windows wiped out by setting the values to zero inside the bright regions that are detected. This is basically a debugging option but may also be useful to remove bright regions in FITS images for example in search of ghosts. One may set in addition the `-r` flag which reverses/complements the set of pixels in *fitsofile*, which means, *fitsofile* shows only the pixels of *fitsfile* that are inside the bright regions.

  Note that the coordinates may be off by factors of 2048 if single-chip images are evaluated in that way and used to configure multi-chip detectors like CARMENES. If a `DETSEC` specification is found in *fitsfile*, it will be used to shift the coordinates; `DETROT90` and/or `DETXYFLI` keywords in *fitsfile* will also be evaluated.

  Also note that `geirs_srreConfig -f ...` just prepares the configuration file. It does *not* construct the pattern files that act on the forthcoming exposures. Therefore, in practise, a semiautomated application of the reset windows will always call pairs of `geirs_srreConfig`, the first with `-f` analysing a previous image, the second with `-i` and `-p` installing the new patterns. For CARMENES and for spectroscopy in general, there will at most be a handful of probably pre-selected reset window sets, because the location of bright spots on the detector depends only on a few parameters of the optical setup (the choice of calibration lamps, the option to rotate the entire detector by 180°,...)

  In almost all cases the *fitsfile* will contain a full image, which means, not an image with darkened areas of the data by production with a previous `srre`. (There may be rare circumstances where deriving the reset window set recursively makes sense, starting with a full image, patching it with a finite cover of reset windows, deriving from that image the bright areas and patching this again...)

  On a side note, this way of extracting the brightest pieces of an image could also be used to generate the configuration files of the `sfdump` command.

  This invocation can only scan images in the primary HDU of the *fitsfile*;[20] if the image is in FITS extensions, it may be copied to a temporary file with that format through the `ftcopy` command of the heatools in the style of

  ```
  ftcopy 'origfile.fits[SCA1_1]' tmp.fits copyall=no
  ```

  or using the `carFits_zech(1)` program with its `-P` option to merge the images in the extensions into a single image in the primary HDU.

[20]this may change in the future

- For administrative reasons and as a public interface to the requirement to save the geometries of the reset windows to the CARMENES FITS files [2], there is also the reverse transformation

  geirs_srreConfig -p *infodir* > *configfile*

  which reads *infodir*/`multi_win_coordinates`.*instru* and creates the *configfile*. This call does not copy windows that are entirely inside the 4-pixel wide eges of the reference pixels (which are probably filler windows created with the other syntax...).

  This kind of invocation of `geirs_srreConfig` is only mentioned to complete the documentation and as a warning against dropping the option `-i`; it is of no value for operation of the instrument.

Disabling As a support for intermediate ROE versions that may not have firmware support of the reset window patterns, GEIRS runs through a set of decisions to consider the `srre` type supported or unsupported. If supported, the `srre` appears in the `Read Mode` submenue in Figure 6.

1. `srre` is not supported on Hawaii-2 detectors and not supported for PANIC.
2. `srre` is supported in all other cases unless all of the following is correct
   - The file `$CAMTMP`/*ip-address* exists, where the IP-address is the currently agitated readout-electronics.
   - There is a line in that file that sets the keyword `CANSRRE` to the value `F`. Note that this uses the FITS syntax for boolean values; in particular the `F` is *not* enclosed with quote marks.

5.7 Tutorial

Basically GEIRS is commanded by a base set of about 10 commands: the read-save pairs and parameters that define integration time, number of repetitions of the readout cycle and the place of the FITS files.

5.7.1 read, sync, save

If GEIRS has just been started up, some default values for the readout mode, integration time, output directory and FITS file name have already been set up. Here is the probably shortest command sequence to generate a single FITS file, which reads out the detector once if no `crep` as used earlier, waits until the frame data have arrived on the workstation, and saves the data (i.e., creates the FITS file):

```
read
sync
save
```

5.7.2 itime, ctype

The basic properties of the exposures are the integration time set with the `itime` and the readout mode (cycle type) set with the `ctype` command prior to one or more reads. The parameters do generally only need to be re-send if they should change; GEIRS remembers the current parameter set and applies it until parameters are modified. An exposure with a single-frame-read of 5 seconds (which is not saved) followed by an exposure of 5 seconds in the line-interlaced-read mode—which is saved in a FITS file— and then an exposure of 10 seconds in the sample-up-the-ramp mode with the default of 2 reads —which is saved in a FITS file—are induced by

```
ctype sfr
itime 5
read
sync
ctype lir
read
sync
save
sync
itime 10
ctype srr
read
sync
save
sync
```

5.7.3 crep, set savepath, next

The cycle repetition `crep` parameter triggers that the subsequent read commands are not creating a single image by reading the detector once (the default) but do this as often as the parameter says. The save path is the directory where new FITS files are created, and the `next` specifies a base name for creating indexed FITS files in the future.

The following sets the read mode to fowler pairs with 4 frames combined into a single image. The integration time (time between associated frames) is set to 5 seconds, and these quad-frames are read 6 times. The resulting 6 images are stored in the files `/dataA/2015-04-01/hah_0001.fits` to `/dataA/2015-04-01/hah_0006.fits` (if the directory exists or permissions allow to generate the directory):

```
ctype mer 4
itime 5
crep 6
read
sync
set savepath /dataA/2015-04-01
next hah_
save
sync
```

5.7.4 save multiple times, sample-up-the-ramp

The `srr` mode is used with an argument which sets the number of reads along a non-destructive read. The integration time which is set independently then implicitly defines the time distance between two reads. In infrared astronomy, usually all frames along the time axis are also saved (for a later independent correction for nonlinearities and dark currents). A total integration time of 60 seconds with 13 reads (therefore $60/12 = 5$ seconds between each read pair) saved into a file srr60_0001.fits with the linearly fitted image and the single frames saved into `srr60_0002.fits` up to `srr60_0014.fits` is executed by the sequence

```
ctype srr 13
itime 60
read
sync
next srr60_
save
sync
save -S
sync
```

The explicit `-S` will not be needed by future GEIRS versions, because by default a `sfdump` command will be activated which always saves all individual CARMENES frames in preparation of the pipeline. If the `srr 13` at the start of this sequence is replaced by `srre 13`, the currently active set of reset windows is applied to each of the frames. So the 12 of the frames in `srr60_0003.fits` to `srr60_0014.fits` have visible dark patterns where the reset windows have been placed. The first frame, `srr60_0002.fits`, is the one read immediately after the initial reset and does not have such an imprinted pattern.

5.8 Python Wrapper

The python interface mentioned in Section 3.1 offers a class `GeirsSrv` with the main functions `expose()` to read out the detector and `genFits()` to save the images into FITS files. There is a helper class `Subwin` to forward subwindows to the command server. The documentation is reproduced in the following pages to give an impression of what `pydoc geirs` will produce while online.

```
Help on module geirs:

NAME
    geirs

FILE
    /home/mathar/work/GEIRS/trunk/lib/python2.7/site-packages/geirs.py

DESCRIPTION
    # This file was automatically generated by SWIG (http://www.swig.org).
    # Version 3.0.2
    #
    # Do not make changes to this file unless you know what you are doing--modify
    # the SWIG interface file instead.

CLASSES
    __builtin__.object
        GeirsSrv
        Subwin

    class GeirsSrv(__builtin__.object)
     |  Constructor with optional host name and TCP/IP port
     |  >>> import geirs
     |  >>> g=geirs.GeirsSrv()
     |  >>> g.genCmd('status')
     |
     |  Methods defined here:
     |
     |  __del__ lambda self
     |
     |  __getattr__ lambda self, name
     |
     |  __init__(self, srvHost='', ipport=8501)
     |      Constructor with optional host name and TCP/IP port
     |      >>> import geirs
     |      >>> g=geirs.GeirsSrv()
     |      >>> g.genCmd('status')
     |
     |  __repr__ = _swig_repr(self)
     |
     |  __setattr__ lambda self, name, value
     |
     |  expose(self, *args)
     |      Start a readout of the detector.
     |      The command has up to four optional arguments.
     |
     |      The first is the exposure time in seconds. A negative argument means that
     |      the same exposure time as the previous readout is used. The argument
     |      with value zero means that the minimum exposure time compatible
     |      with the current readout mode and subwindow set is used.
     |
     |      The second is a
     |      string with the readout mode, typically 'lir' or 'mer' or 'srr' to
     |      name the most common ones. (In case of doubt click on the associated
     |      button of the controls GUI or read the pattern manual.)
     |      If the string is empty, the same readout mode as the previous readout
     |      is used (and defaults to LIR if this is a new session.)
     |
     |      The third is a repetition type, a number larger or equal to one,
     |      which selects the number of images to be created in a row.
     |      If the argument is not used, the same number as in the previous readout
     |      is used.
     |
     |      The fourth is an auxiliary subsample number which is needed to specify
     |      number of samples along the ramp for the 'srr' mode and the number of
     |      double samples in the MER (Fowler).
```

```
 |      >>> g.expose()
 |      >>> g.expose(30,'mer',10,4)
 |
 |  genCmd(self, *args)
 |      Forward a general command of the GEIRS command server to the session.
 |      This is the most versatile handler for GEIRS.
 |      >>> import geirs
 |      >>> g=geirs.GeirsSrv()
 |      >>> g.genCmd('status')
 |      >>> g.expose('lir',10)
 |      >>> g.genCmd('history')
 |      >>> g.genCmd('ls')
 |
 |  genFits(self, saveOpts='', ffileName='', savedir='')
 |      Generate a FITS file with the image(s). The optional three string arguments
 |      are the options of the save command, the name of the FITS file, and
 |      the directory in which the FITS file will be created.
 |
 |      If the directory argument is not used, the same directory as for the previous
 |      file creation will be used (which may be inherited from the last user
 |      if this is a new session, as detailed in the GEIRS manual). Otherwise
 |      the directoy should be a full path name, which will be created if not
 |      yet existing (and if the operating system allows it).
 |
 |      If the file name is missing, it will be derived by upcounting from
 |      the previously saved file names, typically by incrementing the trailing
 |      digits.
 |
 |      The first argument should be a blank-separated list of FITS type choices.
 |      Here '-1' means to create FITS cubes, '-M' means to create FITS image
 |      extensions, '-S' means to store the individual frames instead of the
 |      correlated images, '-z' means to use FITS tile compression and so on.
 |      Details are in the GEIRS manual.
 |
 |      >>> import geirs
 |      >>> g.genCmd('status')
 |      >>> g.expose('srr',3,10)
 |      >>> g.genFits('-1 -M','flori0001','/disk-d/data/ln/20151111')
 |
 |  shutdown(self)
 |      Terminate the GEIRS command server and all GEIRS read and save processes.
 |      >>> import geirs
 |      >>> g=geirs.GeirsSrv('lircs',8501)
 |      >>> g.startup()
 |      >>> g.genCmd('status')
 |      >>> g.shutdown()
 |      >>> quit()
 |
 |  startup(self)
 |      Start the GEIRS command server.
 |      >>> import geirs
 |      >>> g=geirs.GeirsSrv('lircs',8501)
 |      >>> g.startup()
 |      Note that this will first try to shutdown any session which is alive, which
 |      may lead to a spurios intermediate error that the session cannot be reached.
 |      Wait anyway until the standard initialization GUI pops up.
 |      In particular this may terminate a session which is in use by someone else
 |      working under the same LINUX account as yourself.
 |
 |  subwin(self, *args)
 |      Specify the subwindows for use with the next esposures.
 |      The arguments are up to four Subwin objects, which set the new
 |      subwindows. The previous ones will be forgotten by GEIRS. To delete
 |      the subwindows and to continue in full frame mode, send an empty
 |      list:
 |      >>> w1=geirs.Subwin(300,300,400,500)
```

```
     |      >>> w2=geirs.Subwin(1300,300,400,500)
     |      >>> g.subwin(w1,w2)
     |      >>> g.expose()
     |      >>> g.genFits()
     |      >>> g.subwin()
     |
     |  ----------------------------------------------------------------------
     |  Data descriptors defined here:
     |
     |  __dict__
     |      dictionary for instance variables (if defined)
     |
     |  __weakref__
     |      list of weak references to the object (if defined)
     |
     |  host
     |
     |  instru
     |
     |  port
     |
     |  ----------------------------------------------------------------------
     |  Data and other attributes defined here:
     |
     |  __swig_destroy__ = <built-in function delete_GeirsSrv>
     |
     |
     |  __swig_getmethods__ = {'host': <built-in function GeirsSrv_host_get>, ...
     |
     |  __swig_setmethods__ = {'host': <built-in function GeirsSrv_host_set>, ...

    class Subwin(__builtin__.object)
     |  Constructor with window of zero area
     |     w=geirs.Subwin()
     |  Constructor with window coordinates given by FITS string
     |     w=geirs.Subwin('[3:4,7:10]')
     |     w.area()
     |  Constructor with window coordinates as 4-typle of 0-based llx, lly, width and
     |  height
     |     w=geirs.Subwin(3,4,7,10)
     |
     |  Methods defined here:
     |
     |  __del__ lambda self
     |
     |  __getattr__ lambda self, name
     |
     |  __init__(self, *args)
     |      Constructor with window of zero area
     |         w=geirs.Subwin()
     |      Constructor with window coordinates given by FITS string
     |         w=geirs.Subwin('[3:4,7:10]')
     |         w.area()
     |      Constructor with window coordinates as 4-typle of 0-based llx, lly, width and
     |      height
     |         w=geirs.Subwin(3,4,7,10)
     |
     |  __repr__ = _swig_repr(self)
     |
     |  __setattr__ lambda self, name, value
     |
     |  area(self)
     |      Area in units of pixels squared.
     |
     |  boundBox(self, *args)
     |      Compute the window which is the bounding box (super-window) of this window and another
```

```
 |      >>> import geirs
 |      >>> w=geirs.Subwin(1,3,4,5)
 |      >>> w.area()
 |      20
 |      >>> w2=geirs.Subwin(3,5,6,7)
 |      >>> w3=w.boundBox(w2)
 |      >>> w3.area()
 |      72
 |      >>> w3.detsec()
 |      '[2:9,4:12]'
 |      >>> w3.contains(3,4)
 |      True
 |
 |  clipRef(self)
 |
 |  contains(self, *args)
 |      Determine whether a point is inside the window.
 |      The two arguments are the x and y coordinate of the point.
 |      >>> import geirs
 |      >>> w=geirs.Subwin(1,3,4,5)
 |      >>> w.contains(2,10)
 |
 |  countSplit(self, *args)
 |
 |  crossChip(self, *args)
 |
 |  datasec(self, *args)
 |
 |  detsec(self)
 |      Construct a FITS type string representation in brackets.
 |      >>> import geirs
 |      >>> w=geirs.Subwin(1,3,4,5)
 |      >>> w.detsec()
 |
 |  intersection(self, *args)
 |      Compute the window which is the intersection (common area) of this window and another
 |      >>> import geirs
 |      >>> w=geirs.Subwin(1,3,4,5)
 |      >>> w.area()
 |      20
 |      >>> w2=geirs.Subwin(3,5,6,7)
 |      >>> w3=w.intersection(w2)
 |
 |  rotflip(self, *args)
 |
 |  rotflipInv(self, *args)
 |
 |  rotflipPix(self, *args)
 |
 |  ----------------------------------------------------------------------
 |  Static methods defined here:
 |
 |  fullMosaWin = Subwin_fullMosaWin(...)
 |
 |  inHaw2rgRef = Subwin_inHaw2rgRef(...)
 |
 |  ----------------------------------------------------------------------
 |  Data descriptors defined here:
 |
 |  __dict__
 |      dictionary for instance variables (if defined)
 |
 |  __weakref__
 |      list of weak references to the object (if defined)
 |
 |  x1
 |      The x coordinate of the lower left edge of the window.
 |
 |  xsize
 |      The number of pixels horizontally.
 |
 |  y1
 |      The x coordinate of the lower left edge of the window.
 |
 |  ysize
 |      The number of pixels vertically.
 |
 |  ----------------------------------------------------------------------
 |  Data and other attributes defined here:
 |
 |  __swig_destroy__ = <built-in function delete_Subwin>
 |
 |
 |  __swig_getmethods__ = {'fullMosaWin': <function <lambda>>, 'inHaw2rgRe...
 |
 |  __swig_setmethods__ = {'x1': <built-in function Subwin_x1_set>, 'xsize...
 |
 |  h2rgsize = 2048

FUNCTIONS
    GeirsSrv_swigregister(...)

    Subwin_fullMosaWin(...)

    Subwin_inHaw2rgRef(...)

    Subwin_swigregister(...)
```

6 FITS OUTPUT

6.1 Illustrative Example

The primary FITS header generated by the stand-alone GEIRS is illustrated by the following example (extracted with dfits):

```
SIMPLE  =                    T
BITPIX  =                   16
NAXIS   =                    2 / 2
NAXIS1  =                 2048
NAXIS2  =                 2048
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
BSCALE  =                   1.
BZERO   =               32768. / [adu] real = bzero + bscale*value
BUNIT   = 'adu     '           / [adu]
MJD-OBS =         56610.398151 / [d] Modified julian date 'days' of observation
DATE-OBS= '2013-11-14T09:33:20.2482' / [d] UT-date of observation end
DATE    = '2013-11-14T09:40:59.0409' / [d] UT-date of file creation
UT      =         34400.248236 / [s] 09:33:20.2482 UTC at EOread
LST     =           46667.9276 / [s] local sidereal time: 12:57:47.928 (EOread)
ORIGIN  = 'Centro Astronomica Hispano Aleman (CAHA)'
OBSERVER= 'master  '
TELESCOP= 'CA-2.2  '
FRATIO  = 'F/08    '           / [1]
OBSGEO-L=            -2.546135 / [deg] telescope geograph. longit.
OBSGEO-B=            37.223037 / [deg] telescope geograph. latit.
OBSGEO-H=                2168. / [m] above sea level
LAMPSTS = '        '           / calib. lamp
INSTRUME= 'Panic   '
CAMERA  = 'HgCdTe (4096x4096) IR-Camera (4 H2RGs)'
PIXSCALE=                 0.45 / [arcsec/px]
ELECGAIN=                 2.01 / [ct] electrons/DN
ENOISE  =                  12. / [ct] electrons/read
ROVER   = 'MPIA IR-ROelectronic Vers. 3' / Version det. electronics
WPOS    =                    5 / [ct] number of GEIRS wheels
W1POS   = 'COLDSTOP22'
W2POS   = 'KS      '
W3POS   = 'OPEN    '
W4POS   = 'OPEN    '
W5POS   = 'OPEN    '
FILTER  = 'NO      '           / filter macro name of filter combinations
FILTERS = 'OPEN    '           / combination of all filters used (single OPEN)
STRT_INT=         33398.779494 / [s] '09:16:38.7795' start integration (UT)
STOP_INT=         34400.185113 / [s] '09:33:20.1851' stop integration (UT)
RA      =           216.863294 / [deg] R.A.: 14:27:27.2
DEC     =            42.714232 / [deg] Dec.: +42:42:51
EQUINOX =                2000. / [a] Julian Epoch
OBSEPOCH=          2013.866673 / [a] Julian Epoch
AIRMASS =             1.051181 / [1] airmass
HA      =           337.594738 / [deg] H.A. '22:30:22.74'
T_FOCUS =                  30. / [mm] telescope focus
CASSPOS =                   0. / [deg] cassegrain position rel. to NSEW
```

```
OBJECT  = 'no object'
FILENAME= 'Illum_srr30_300s_0214.fits'
DITH_NO =                    0 / [ct] dither step
EXPO_NO =                  235 / [ct] exposure/read counter
TPLNAME = '        '           / macro/template name
TIMER0  =                67145 / [ms]
TIMER1  =               932855 / [ms]
TIMER2  =            865710408 / [us]
PTIME   =                    2 / pixel-time-base index
PREAD   =                10000 / [ns] pixel read selection
PSKIP   =                  150 / [ns] pixel skip selection
LSKIP   =                  150 / [ns] line skip selection
READMODE= 'sample.ramp.read'   / read cycle-type
IDLEMODE= 'break   '           / idle to read transition
IDLETYPE= 'ReadWoConv'         / idle cyle-type
SAVEMODE= 'o2.single.corr.read' / save cycle-type
CPAR1   =                   50 / cycle type parameter
ITIME   =                1000. / [s] (on chip) integration time
CTIME   =          1001.370302 / [s] read-mode cycle time
CRATE   =             0.000999 / [Hz] read-mode cycle rate
HCOADDS =                    1 / [ct] # of hardware coadds
EMSAMP  =                    0 / [ct] electronic multi-sampling
PCOADDS =                    1 / [ct] # of coadded plateaus/periods
SCOADDS =                    1 / [ct] # of software coadds
FRAMENUM=                   47 / of 50 saved
NCOADDS =                    1 / [ct] effective coadds (total)
DETSEC  = '[1:2048,2049:4096]' / [px] xrange and yrange of window
DATASEC = '[5:2044,5:2044]' / [px] xrange and yrange of science data
FRAMENUM=                    1 / of 1 saved
SKYFRAME= 'unknown '
DETSIZE = '[1:4096,1:4096]'    / [px] x-range, yrange of full frame
CHIPSIZX=                 2048 / [px] single chip pixels in x
CHIPSIZY=                 2048 / [px] single chip pixels in y
B_EXT1  =             2.299805 / [V] external bias 2355
B_EXT2  =             2.685547 / [V] external bias 2750
B_EXT3  =             2.685547 / [V] external bias 2750
B_EXT4  =             2.685547 / [V] external bias 2750
B_DSUB1 =             1.199785 / [V] det. bias voltage DSUB 2614
B_DSUB2 =             1.744141 / [V] det. bias voltage DSUB 3800
B_DSUB3 =             1.744141 / [V] det. bias voltage DSUB 3800
B_DSUB4 =             1.744141 / [V] det. bias voltage DSUB 3800
B_VREST1=             0.699951 / [V] det. bias voltage VRESET 1525
B_VREST2=             1.193359 / [V] det. bias voltage VRESET 2600
B_VREST3=             1.193359 / [V] det. bias voltage VRESET 2600
B_VREST4=             1.193359 / [V] det. bias voltage VRESET 2600
B_VBIAG1=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG2=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG3=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG4=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VNBIA1=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA2=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA3=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA4=                   0. / [V] det. bias voltage VNBIAS 0
B_VPBIA1=                   0. / [V] det. bias voltage VPBIAS 0
B_VPBIA2=                   0. / [V] det. bias voltage VPBIAS 0
B_VPBIA3=                   0. / [V] det. bias voltage VPBIAS 0
```

```
B_VPBIA4=                    0. / [V] det. bias voltage VPBIAS 0
B_VNCAS1=                    0. / [V] det. bias voltage VNCASC 0
B_VNCAS2=                    0. / [V] det. bias voltage VNCASC 0
B_VNCAS3=                    0. / [V] det. bias voltage VNCASC 0
B_VNCAS4=                    0. / [V] det. bias voltage VNCASC 0
B_VPCAS1=                    0. / [V] det. bias voltage VPCASC 0
B_VPCAS2=                    0. / [V] det. bias voltage VPCASC 0
B_VPCAS3=                    0. / [V] det. bias voltage VPCASC 0
B_VPCAS4=                    0. / [V] det. bias voltage VPCASC 0
B_VBOUB1=                    0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB2=                    0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB3=                    0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB4=                    0. / [V] det. bias voltage VBIASOUTBUF 0
B_REFSA1=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA2=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA3=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA4=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFCB1=                    0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB2=                    0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB3=                    0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB4=                    0. / [V] det. bias voltage REFCOLBUF 0
TEMP_A  =                -9999. / [K] sensor A (-10272.15 C)
TEMP_B  =                -9999. / [K] sensor B (-10272 C)
PRESS1  =              0.000372 / [Pa] (3.720e-09 bar)
TEMPMON =                     8 / [ct] # of temp. 2013-11-14 09:00 monitrd loc. t
TEMPMON1=             73.740997 / [K] (-199.41 C) 2013-11-14 10:32 Sensor 1
TEMPMON2=             74.575996 / [K] (-198.57 C) 2013-11-14 10:32 Sensor 2
TEMPMON3=                74.069 / [K] (-199.08 C) 2013-11-14 10:32 Sensor 3
TEMPMON4=             73.061996 / [K] (-200.09 C) 2013-11-14 10:32 Sensor 4
TEMPMON5=            125.110001 / [K] (-148.04 C) 2013-11-14 10:32 Sensor 5
TEMPMON6=             76.603996 / [K] (-196.55 C) 2013-11-14 10:32 Sensor 6
TEMPMON7=             86.221001 / [K] (-186.93 C) 2013-11-14 10:32 Sensor 7
TEMPMON8=            123.300003 / [K] (-149.85 C) 2013-11-14 10:32 Sensor 8
CREATOR = 'GEIRS : rjm-r709M-s64 (Nov  8 2013, 17:33:58), Panic_r73M'
COMMENT = 'no comment'
OTKEYWRD=    'text'  / example of add. PANIC keyword
END
```

This is generated by running PANIC, because the number of keywords is roughly a maximum for this instrument . The outcome *is* different for other instruments.

GEIRS generates FITS images with 2 bytes per pixel when storing single frame data (created either through some single-frame read cycle type or by using the `-S` switch of the `save` command or from the single frame dumps of the guide mode), and images with 4 bytes per pixel for all the others (created by correlated cycle types). So the simplest filter for fishing for FITS files with correlated images in the local directories of CARMENES—assuming no data cubes were stored—is to select FITS files larger then 30 MB, for example:

```
find . -name "*.fits" -size +30M
```

because the single full frame files are slightly larger than 16 MB and the correlated full frame files are sligthly larger than 33 MB.

6.2 Online Keyword Modification

Section 6.2 is irrelevant for CARMENES because there are no auxiliary FITS data on the NIR computer.

Supervisor software can funnel primary header keyword lines into the new FITS files by writing them into the `$CAMTMP/geirsPhduAdd.`*instrument* or `$CAMTMP/geirsPhduAdd.`*instrument_i* file before the FITS file is generated with the `save` command. Here *i* is a small integer from 1 to 5. The effective line set is the concatenation of the lines in these files in the natural order, as if first `geirsPhduAdd.`*instrument*, then `geirsPhduAdd.`*instrument*_1, etc and finally `geirsPhduAdd.`*instrument*_5 was acting on the raw default FITS headers. Having a range of six files at the disposal allows multiple subsystems to update or erase these files with different frequencies. The current convention is that

1. `$CAMTMP/geirsPhduAdd.`*instrument* is manipulated by online tools,
2. `$CAMTMP/geirsPhduAdd.panic_2` for any further generic cleanup;

In general GEIRS cleans up these files each time it is started up, because some online tools forget to erase their associated files when they are shut down; this would leave obsolete contents in these files if GEIRS is afterwards started as a standalone program which then erroneously pile up in FITS headers.

This mechanism is not synchronized; GEIRS reads the contents and appends these lines to the header just before composing the FITS file. Obviously there is some risk of loosing information if the frame rate exceeds 1 Hz and the supervisor software updates that file at a similar frequency.

The functionality with the fedithead syntax is available: The files can remove, replace and add keywords of the forthcoming FITS header all in one step. A set of proposals for such configuration files on a per-instrument basis is in `$CAMHOME/`*branch*`/admin/geirsPhduAdd.*` in the source code.

6.3 GEIRS Core Keywords

Some keywords remain after the purging mentioned above; there are FITS mandatory keywords concerning the image dimensions and bits-per-pixel format [10], plus the following:

- `MJD-OBS =          56433.495665 / [d] Modified julian date 'days' of observation`

  This time refers approximately to the time when the FITS header was created, and this happens after the `STOP_INT` which is more relevant to the observation.

- `DATE-OBS= '2013-05-21T11:53:45.4834' / [d] UT-date of observation end`

- `DATE    = '2013-05-21T11:54:17.5317' / [d] UT-date of file creation`

  `DATE` is just mentioned for completion. According to the FITS standards, this time stamp will be updated and overwritten each time some other layer of the software modifies the images or keywords.

- `UT      =          42825.483405 / [s] 11:53:45.4834 UTC at EOread`

- `LST     =          73883.640000 / [s] local sidereal time: 20:31:23.640 (EOread)`

  The value of the local sidereal time is to be considered an estimate based on the observatory coordinates. Effects of precession, nutation and so on are completely neglected [15, 16].

-
  ```
  ORIGIN  = 'Mount Graham, MGIO, Arizona'
  TELESCOP= 'LBT'
  FRATIO  = 'F/15'               / [1]
  OBSGEO-L=          -109.889000 / [deg] telescope geograph. longit.
  OBSGEO-B=            32.701300 / [deg] telescope geograph. latit.
  OBSGEO-H=          3221.000000 / [m] above sea level
  ```

  These keywords related to the name and location of the observatory are hardcoded in the software. The `OBSGEO` keywords comply with the proposal on WCS coordinates [17]. Three additional keywords `OBSGEO-X`, `OBSGEO-Y`, and `OBSGEO-Z` will be created if the preprocessor variable `GEIRS_FITS_OBSGEOKW` is defined at compile time; this is switched off by default.

-
  ```
  OBSERVER= 'mathar'
  ```

  This is equivalent to the most recent `observer` command received by GEIRS (Section 5.3) or submitted with the start-up GUI, Figure 4.

-
  ```
  INSTRUME= 'Nirvana'
  CAMERA  = 'HgCdTe (2048x2048) IR-Camera'
  OPTIC   = 'very high res.'
  PIXSCALE=             0.005110 / [arcsec/px]
  ```

  These keywords are constants hardcoded in the software.

-
  ```
  EGAIN=             2.010000 / [ct] electrons/DN
  ENOISE  =            14.000000 / [ct] electrons/read
  ```

  Electronic gain and noise are hardcoded constants. This noise generally refers to the `lir` read mode [18] . For PANIC's `rrr-mpia` mode however, a separate set of these 2 parameters for each of the 4 chips has been measured, so these 8 parameters are copied into the header cards when PANIC is in fact using that readout mode. The noise in the actual FITS images is a function of (amongst others) the readout modes, electronic sampling etc as surveyed in [12]. For instruments with more than one detector chip, both keywords are adorned with 1-based integers: `EGAIN1`, `EGAIN2` and so on.

-
  ```
  ROVER   = 'MPIA IR-ROelectronic Vers. 3' / Version det. electronics
  ```

  A (rough) characterization of the MPIA readout electronics. The FPGA program versions are not reported in the header.

-
  ```
  STRT_INT=         42822.774880 / [s] '11:53:42.7749' start integration (UT)
  STOP_INT=         42825.483222 / [s] '11:53:45.4832' stop integration (UT)
  ```

  These two UTC time stamps are the most accurate timing information available for astrometry in any follow-up pipeline. The `STOP_INT` is slightly earlier than the end-of-read time stamp in `UT`.

-
  ```
  EQUINOX =                2000. / [a]
  OBSEPOCH=          2013.384920 / [a]
  ```

  Julian year of the RA and DEC information and of the data acquisition.

  Note that the precision of 1×10^{-6} years in the numerical value of a year is only equivalent to ≈ 30 seconds.

-
  ```
  POINT_NO=                    0 / [ct] pointing counter
  DITH_NO =                    0 / [ct] dither step
  EXPO_NO =                    1 / [ct] exposure/read counter
  ```

The three numbers are modified by the `counter` command (Section 5.3). The intent of the `POINT_NO` and `DITH_NO` variables is to keep track of dithered (nodding) imaging with imaging optics. It is entirely up to the software/operator that drives GEIRS whether these two may differ from zero.

The regular update of `EXPO_NO` if not intervened by such commands is to start at one as GEIRS is started, then to increase by one for each `read`—where it does not matter if the FITS file name is changed in between. If the cycle repetition factor is chosen larger than one (`Repeat` in Figure 6 or command `crep` in Section 5.3), the `EXPO_NO` is the same in all the individual files that are created.

- `FILENAME= 'normal0003.fits'`

  The filename of the FITS file in the local file system of the detector workstation as requested by the observer.

  If the source file `save.c` is compiled with the preprocessor option `GEIRS_CREA_SAVE_LINK` defined, a link from the file given by `FILENAME` to a file with canonical name derived from `STRT_INT` is created at run time. This may facilitate robotic archival software and even be a trivial form of overwrite protection, but has been disabled by default because —in the eyes of the principal GEIRS developer–links may confuse operators with little knowledge of UNIX-type operating systems.

- `TPLNAME = ''                   / macro/template name`

  Name of the macro file (Section 5.4) if applicable. Empty if the observation was driven on a command-by-command basis.

-
  ```
  TIMER0  =                 2667 / [ms]
  TIMER1  =                 2667 / [ms]
  TIMER2  =                    0 / [us]
  ```

  Three time intervals that help debugging the GEIRS timing.

-
  ```
  PTIME   =                    1 / pixel-time-base index
  PREAD   =                10000 / [ns] pixel read selection
  PSKIP   =                  150 / [ns] pixel skip selection
  LSKIP   =                  150 / [ns] line skip selection
  ```

  Four parameters that detail in which way the fundamental clock of the ROE was subdivided to drive some basic actions on the detector chip.

-
  ```
  READMODE= 'line.interlaced.read' / read cycle-type
  IDLEMODE= 'wait'               / idle to read transition
  IDLETYPE= 'ReadWoConv'         / idle to read transition
  SAVEMODE= 'line.interlaced.read' / save cycle-type
  ```

  These four parameters define the reset-read pattern of gathering the frames, how the read-out electronics clocks the detector while no data are taken, and in which way the frames send from the ROE are packed into FITS images (by averaging, subtracting, fitting. . .) by GEIRS. See [6, 12].

  The `READMODE` defines the scheme of patterns and timings in use while the frames were generated by the detector and ROE and arrived on the workstation. The value of `SAVEMODE` may be different if the mode was changed (either via the button labeled `Read Mode` in Figure 6 or with the `ctype` command or by using the `-S` option of the `save` command) before executing `save`. In this case the packaging of frames into files of FITS images (by subtraction, averaging. . .) is modified by the save procedure and departs from the “standard” associated with the read mode. [The software allows to save the same set of frames more than once and switching the mode without any intermediate read. This is helpful if one wants to store correlated images but also the bare frames for debugging purposes.]

- `CPAR1   =                    1 / cycle type parameter`

  This is the integer parameter given to the ctype command (Section 5.3), basically the number of frames that are correlated in the multi-correlated modes (Fowler, sample up the ramp. . .) [19, 20]. The value is actually a filtered version of the command in case that the associated save-mode does not support a variable parameter.

  If the integration along the ramp was disrupted with the abort command, the value is still the one that was scheduled when the read started, not the (smaller) number of frames that were actually read.

- `ITIME   =             2.667059 / [s] (on chip) integration time`

  The scheduled integration time. The actual integration time may have been shorter if the exposure was aborted (see EXPTIME).

- `CTIME   =             5.345815 / [s] read-mode cycle time`
- `CRATE   =             0.187062 / [Hz] read-mode cycle rate`

  The value is basically superfluous because it just shows the inverse of the cycle time.

- `HCOADDS =                    1 / [ct] # of hardware coadds`

  Hardware coadding was an option with other instruments; this parameter always equals 1 in the current versions of the read-out electronics.

- `EMSAMP  =                    0 / [ct] electronic multi-sampling`

  The electronic multi-sampling correlated with the roe command (Section 5.3). Values of 0 or 1 mean sampling once with the ADCs, otherwise the value may be 2 or 4 with the benefit of noise reduction [3, §2.5.4]

- `PCOADDS =                    1 / [ct] # of coadded plateaus/periods`
- `SCOADDS =                    1 / [ct] # of software coadds`

  Software coadding is selected by the option -i of the save command (Section 5.3) and indicates how many frames have been added to generate one image.

- `SWMSAMP =                    0 / [ct] # software multisampling`
- `NCOADDS =                    1 / [ct] effective coadds (total)`

  The product of HCOADDS and SCOADDS.

- `EXPTIME =             2.667059 / [s] total integ. time`

  The exposure time spent on creating an image. Usually this equals the integration time. If the data have been created using a repetition factor larger than one (command crep and keyword NEXP), EXPTIME still is the time for the single image, in case of saving the images in a FITS cube the time for each individual slice in the cube. If the data have been saved with the -i option of the save command, EXPTIME is the product of NEXP and ITIME, because each pixel in the image represents the arithmetic sum of the pixels in the individual exposures.

  If the exposure was aborted, ITIME is the scheduled integration time, but EXPTIME the (shorter) exposure time derived from the arrival time of the frames on the GEIRS computer.

- `FRAMENUM=                      1 / OF 1 as save range`

  1-based enumeration of the images or of the frames (if single frames are stored). For images this is only relevant if the `Repeat` option was used to generate a series exposures with a constant set of parameters (`Repeat` entry in Figure 6 and `crep` in Section 5.3).

- `SKYFRAME= '(tmp-img)'`

  Generally an empty string, but a file name if some other FITS image has been subtracted to obtain the current FITS image, and a string in parentheses if this image was taken from another frame in the online image buffer.

- `DETSEC  = '[1:2048,1:2048]'    / [px] xrange and yrange of window`

  Coordinates of the detector window in the FITS image. The value is the same as `DETSIZE` if the full window has been read out.

- `DATASEC = '[5:2044,5:2044]'    / [px] xrange and yrange of science data`

  Coordinates of the detector window in the FITS image. This is basically the same as `DETSEC` but smaller for the case of Hawaii-2 RG detectors if some pixels fall into the 4-pixels frame along the edges.

-
  ```
  DETSIZE = '[1:2048,1:2048]'    / [px] x-range, yrange of full frame
  CHIPSIZX=                 2048 / [px] single chip pixels in x
  CHIPSIZY=                 2048 / [px] single chip pixels in y
  ```

  Three values that describe the geometry of the detector and which are always the same because all instruments use Hawaii-2 or Hawaii-2 RG detectors.

-
  ```
  B_EXT1  =             2.530273 / [V] external bias
  B_DSUB1 =             0.000000 / [V] det. bias voltage DSUB
  B_VREST1=             0.500000 / [V] det. bias voltage VRESET
  B_VBIAG1=             3.222656 / [V] det. bias voltage VBIASGATE
  ```

  Four values per chip (Hawaii-2) or 10 values per chip (Hawaii-2 RG) that show the voltages applied to the detector chip, which are set by DAC's and are defined by keywords in the GEIRS patterns (and potentially modified by the `bias` command). The comments show the DAC inputs in the range 0–4095 for the most recent GEIRS version.

- `CREATOR = 'GEIRS : rjm-r700M-g64 (May 16 2013, 15:51:59), Nirvana'`

  GEIRS SVN branch, version, timestamp and pattern directory.

-
  ```
  EOFRM000 = ...
  EOFRM001 = ...
  EOFRM002 = ...
  ```

  These keywords denote end-of-frame time of arrival of the last byte of the frames in the GEIRS DMA buffers. The units are the same as the `STRT_INT` and `STOP_INT` units, i.e., UT seconds in the range from 0 to 24×3600 (the number of seconds per day). Details:

  – More precisely: the keyword `EOFRM000` is not a time that marks the end of a frame but a start of triggering the read; therefore the time difference between `EOFRM000` and `EOFRM001` depends on the idle modes. The number of values with postive index is the product of `CPAR1` and `NEXP`, covering the entire set of frames. If the exposure was aborted, the number of values is smaller.

  - For the correlated double-sampling modes, the arrival of the reset-frame is not measured and the even indices (with the exception of 000) are absent.
  - Where `CAMDPORTS` equals 2 (Section 3.2), each time is the mean of the two arrival times of the parallel streaming through both fibers.
  - The first differences are added in the comments and ought to be basically the same on the milliseconds level.

-
  ```
  PERCT025 = ...
  PERCT050 = ...
  ...
  PERCT500 = ...
  ...
  PERCT975 = ...
  ```

  provide the ADU levels of 2.5%, 5%,...97.5% percentiles. The value of `PERCT500`, for example, is the median ADU in the corresponding image or frame. The data allow a quick look at the saturation level inside the image. If the keywords are generated, a quick extraction of the median for example of a sequence of FITS files can be generated with a script like

  ```
  #!/bin/bash

  cd .../2015-03-02 # move to the data directory
  for j in Linr*.fits ; do   # loop over the FITS files of interest
          # extract PERCT500 (the 50.0 percentile) from extension 1
          dfits -x 1 $j.fits | fgrep PERCT500  | awk '{print $6}' ;
  done
  ```

  or for named extensions

  ```
  #!/bin/bash

  cd .../2015-03-02 # move to the data directory
  for j in Linr*.fits ; do   # loop over the FITS files of interest
  # copy the extension of interest to the primary header of tmp.fits
          rm tmp.fits
          ftcopy "$j[SCA1]" tmp.fits copyall=no ;
          # extract PERCT500 (the 50.0 percentile) from primary header of tmp.fits
          dfits tmp.fits | fgrep PERCT500  | awk '{print $6}' ;
  done
  ```

-
  ```
  RESWN001 = ...
  RESWN002 = ...
  ```

  indicate the location and dimension of reset windows in the `srre` mode. The indices in the keywords are generally *not* the same as in the operator's initial files.

The keywords `ALT`, `AZ` and `PARANG` appear only if activated at compile time in `Makefile.am` as documented in the file `INSTALL` of the source distribution. Because GEIRS is not an astrometry package, this is disabled by default.

The keywords `CHECKSUM` and `DATASUM` appear if the associated `save` option is used.

To simplify looking at the images with `ds9`, GEIRS places a WCS coordinate system on the two CARMENES FITS extensions. This has its origin at the middle of the detector plane in the gap between the two chips, and measures millimeters along the right (X) and up (Y) direction in the optical plane (i.e., ignoring the rotations and flips of the image).

6.4 Image Location

For Hawaii-2 RG chips (PANIC, CARMENES, Luci1, Luci2), GEIRS includes the four reference pixels along each of the four edges into the FITS images (if they are inside any of the subwindows). Postprocessing programs ought be aware of the fact that these pieces of the images do *not* contain regular data, and that the usable region is only a maximum of 2040 × 2040 pixels per chip.

Using (or not using) the `save` options `-1` (requesting FITS cubes) and/or `-M` (requesting the multiple extension FITS format) leads to four different layouts of the FITS files:

- Without the two options, each window of each image is stored in the first (primary) HDU of a single file. This leads to the largest number of files and the smallest individual sizes of the files. In the extended syntax of the form `filename[..extname..]`, where the piece in brackets is the name of the extension as shown in the `EXTNAME` keyword of the HDU, this is:

  ```
  fname_0001_win1.fits # 1st window, first image/frame
  fname_0001_win2.fits # 2nd window, first image/frame
  ...
  fname_0002_win1.fits # 1st window, second image/frame
  fname_0002_win2.fits # 2nd window, second image/frame
  ```

  The first part of the file name is under user control with the standard mechanisms (Section 5.3), but not the trailing part of the underscore, `win`*i* and suffix.

- With `-1`, each window is stored in a separate file. Each image is a slice in a FITS cube of the primary HDU.

  ```
  fname_0001_win1.fits # first window, all frames as a cube in primary HDU
  fname_0001_win2.fits # second window, all frames as a cube in primary HDU
  ```

  The first part of the file name is under user control with the standard mechanisms (Section 5.3), but not the trailing part of the underscore, `win`*i* and suffix.

- With `-M`, each image is stored in a single file; the second, third HDU and so on contain the various windows of the image.

  ```
  fname_0001[win1_1].fits # 1st image/frame, first window on first chip
  fname_0001[win1_2].fits # 1st image/frame, second window on first chip
  fname_0001[win2_1].fits # 1st image/frame, first window on second chip
  ...
  fname_0002[win1_1].fits # 2nd image/frame, first window on first chip
  fname_0002[win1_2].fits # 2nd image/frame, second window on first chip
  fname_0002[win2_1].fits # 2nd image/frame, first window on second chip
  ```

In general, the extension name starts with `win`, attaches a number (starting at 1) for the infrared chip, an underscore, and a another number (starting again at 1) as the index of the window in the set of all windows on that chip. For detectors with a single chip (LUCI1, LUCI2, LN), the first number is always 1.

- With `-1` *and* `-M`, all images of an exposure are stored in a single file. Individual windows are stored as a FITS cube in the first, second HDU and so on, where the layers in the cube are formed by the consecutive images. (If there is only one exposure, the format is automatically reduced to the standard 2D image format, which means the `NAXIS` keyword becomes 2.) This is the best organized display for multi-exposures with more than one window, but yields the largest files.

```
fname_0001[win1_1].fits # first window on first chip, all frames as cubes
fname_0001[win1_2].fits # second window on first chip, all frames as cubes
fname_0001[win2_1].fits # first window on second chip, all frames as cubes
...
```

In summary, without `-M` all images are in the primary HDU, with `-M` no images are in the primary HDU. For CARMENES the `-M` is permanently switched on, even if the option is not added to the `save` command.

The extension `SCA1` contains the data of the upper of the two detector chips (which is addressed with index 1 and `det1` in the commands), the extension `SCA2` contains the data of the lower of the two detector chips (which is addressed with index 2 and `det2` in the commands): Figure 35.

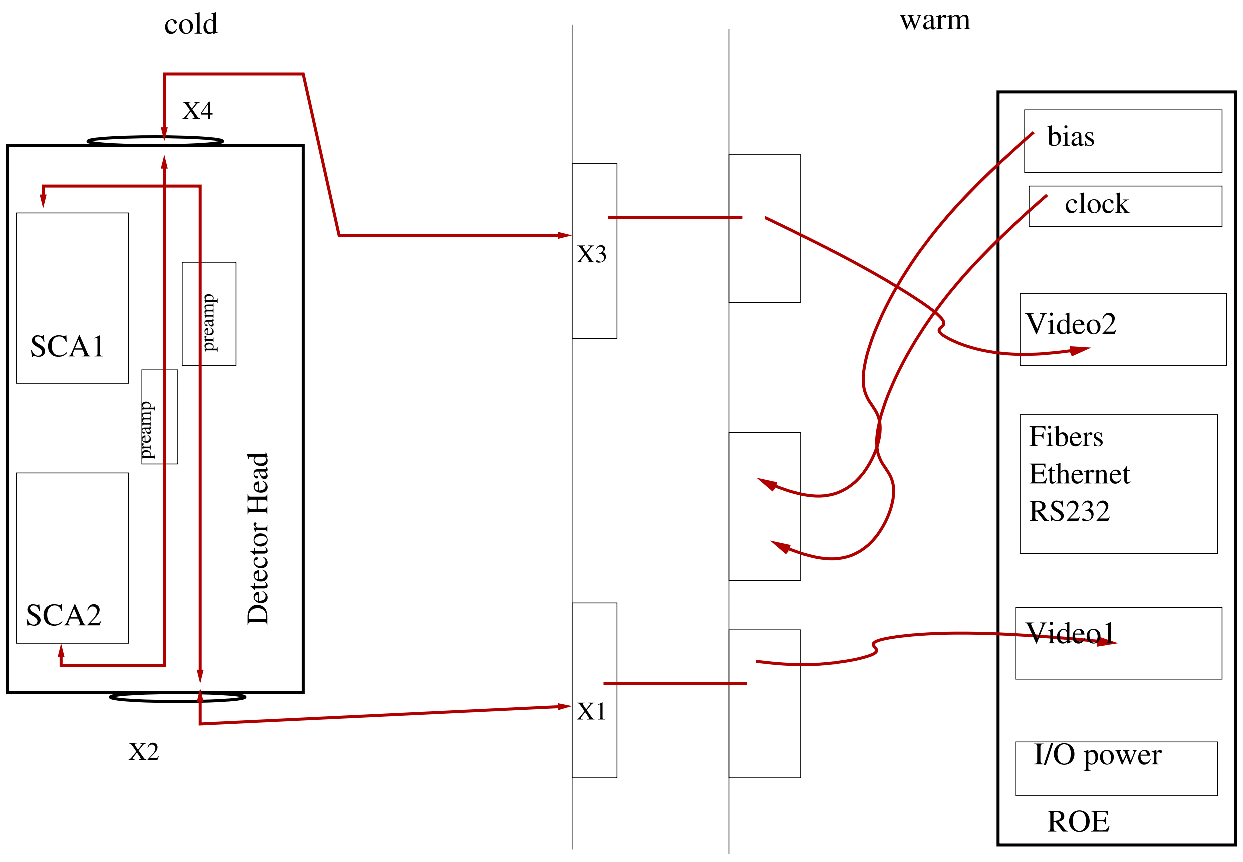


Figure 35: Carmenes signals and connectors: alignments relativ to ceiling and floor.

After a change request of M. Zechmeister in late 03/2015, the FITS coordinate system in the detector plane was changed by modification of the parameters (Section 3.2) such that `SCA1` is shown to the right in the online display and placed at the horizontal FITS coordinates $2049 \le x \le 4096$, and that `SCA2` is shown to the left in the online display and is placed at the horizontal FITS coordinates $1 \le x \le 2048$ (Figure 15). In addition there is flip around the long axis of the mosaic; FITS images are equivalent to looking at the detector plane from the *rear* side. This flip also causes a different orientation of the FITS images compared to Figures 29 onwards of the Optics FDR [21].

GEIRS adds a WCS coordinate system named `Det. Plane` to the FITS image extensions. Its two axes are measured in millimeters. The origin is in the middle of the gap between the two infrared chips. The first coordinate is along the direction horizontal-right in the laboratory if looking onto the surface of the chips, equivalent to up in the FITS images. The second coordinate is along the direction up in the laboratory, which means the direction right in the FITS images. The determinant of the WCS matrix is negative. Altogether this means sticking a left-handed coordinate pair to the FITS images which represents a right-handed coordinate pair in the laboratory frame coordinates.

Any postprocessing software knows from the `DATASEC` value which region of the full detector is covered by the window of any particular HDU, and retrieves the number of frames or images from the `NAXIS` and `NAXIS3` values.

Single-frame output from GEIRS uses 16-bit data types in the images; correlated output uses 32-bit data types. There are rumours that there are LBT guidelines that require images to be always of a 32-bit data type (wasting fifty percent of disk space in the first case). Such a postprocessing can be installed by calling chimgtyp from within `QueueFiles`. The current name convention for the extensions (`EXTNAME`) is `Q`d_w for PANIC, `SCA1|SCA2_`w for CARMENES, and `wind`d_w for the other instruments, where d is the chip number from 1 to 4 and $w \ge 1$ is a window number. If the operator did not use subwindows, w is always 1. The index w is not necessarily the same as used in the `subwin` command; exceptions occur if

1. the operator skipped numbers,
2. defined but disabled some of the intermediate subwindows,
3. or let some windows stretch over multiple chips.

The physical order of the MEF extensions is by window number w, which just reflects the operator's liking for the order of enumeration in the `subwin` command. If a window has been split because it covers more than one detector, the split windows stay close together huddled in a group, so there is an "inner" or "fast" loop over the chips then.

6.5 Guide Mode

The guide mode refers to saving *uncorrelated single* frame snapshots to a data interface—which just means to FITS or to raw binary files for now—while the packages of the 16-bit data of the (nondestructive) readouts arrive in the kernel buffers.

The name *guide mode* vaguely indicates that the information extracted this way from an incremental read-while-integrate exposure may be used to steer other optical elements of the telescope looking at jitters and shifts/drifts in these images. The aim is that one does not need to terminate the readout cycle with `abort` or wait for the end of the integration time to get hands on the images. One can then analyze the FITS frames with an online tool similar to looking at the individual frames by selecting `Frm:` with the `Img` button of the real-time display (Figure 15).

The principle of operation is that these image data are stored with the frame arrival frequency to individual files without effecting otherwise the mixes of resets, readout patterns and windows. This almost always implies that the treatement of the data within the guide mode is bestowed with its local definition of data sections (windows) so the GEIRS data interface may cut out only those data essential to monitoring the data quality such that

1. the computational load due to the additional disk transfer (including the load by the reading application) is kept low.
2. the risk of stalling the main data processing task enforced by additional locking mechanisms with these buffers remains small. (The data interface works by drawing local copies of the standard shared memory data buffers parallel to the `read` process; if it is too slow, the standard procedure may fall behind its schedules working through the "read" and the "save" pairs of buffers.)

To stabilize the operation/mechanism against overloading by too frequent or too large window files, the implementation simply skips frames that are scheduled to be created while a previous frame is still being worked on.

The operator may in addition slow down the dumping frequency below once per read with two keywords in the configuration file: The relation between the number of created FITS files N_F, the integer subsampling factor s and the number of frames N (effective, optionally after `abortion`) in the RAM is

$$N_F = 1 + \lfloor \frac{N-1}{s} \rfloor. \tag{7}$$

Also note that this final `save` is not flagged as done at the end of the exposure (because obviously that computes a correlated image from all the previous frames and is of a very different kind of quality, depending on the `save` mode).

There requirements to install/activate this concurrent eaves-dropping mechanism are:

1. The `sfdump` (single frame dump) command (Section 5.3) is called to tell GEIRS which sections of the windows (or full frame) are to be written where. The creation of these pixel data files happens up to the time it is switched off with `sfdump off` or until GEIRS is shut down. The `sfdump` command actually points to a configuration file that contains the bounding boxes of the windows' geometries, and auxiliary parameters.
2. The readout mode is one of the multi-correlated modes (Fowler, sample-up-the ramp,...). The single-frame dumps are not created for uncorrelated or single-correlated types, because the reset frame is supposedly useless and the next frame anyway to be saved in these cases. (One does not need to call `sfdump off` if a sequence of different readout modes is started that mixes double and multi-correlated modes. The creation of the intermediate files will simply pause if the current mode is not a multi-correlated one.)

The ADC data within the windows specified in the configuration file named in the `sfdump` are written either in

- a MEF format with `BITPIX=16` and one window per extension if the `RAWF` flag in the configuration file is `F` or not given.
- or a binary stream with two bytes per pixel in the endianess of the GEIRS computer window-after-window if the `RAWF` flag in the configuration file is `T`.[21]

[21] This file format can for example be read with `od -d ...`.

The intended scenario is that the monitoring programs are using the commands like `sfdump sfdump.cfg` once, and edit the file `sfdump.cfg` after a `save` and prior to the next `read` if the window number or geometry needs to be adjusted. GEIRS re-reads the configuration file (that was `sfdump.cfg` in the example above) for each frame arriving from the detector, so editing the file while a `read` is ongoing may lead to unpredictable results.

The regions specified in the configuration file do not need to aligned in any particular way with the hardware and software windows specified by the `subwin` command. They may overlap. Any pixels of the regions that fall outside the subwindows which actually are covered by the detector data are filled with zeros.[22]

The implementation is by default dumping data into a directory without any overwrite protection[23] and iterating over the same base file names during every new read. We assume that these windows contain scratch data for online processing and do not have any lasting value, and in this way avoid that an extra monitor on available disk space in this part of the file system is needed.

[22]The current implementation also copies reference pixels of Hawaii2-RG detectors into the regions, which may change in the future.

[23]i.e., the definition of the `clobber` command are ignored

7 MOTOR CONFIGURATION

Section 7 is only applicable to PANIC, not to the other instruments

Motors are either moved individually with the `wheel` command or all in parallel by binding a specific set of positions of a macro name and calling the `filter` command with one of the filter macro names.

7.1 Files

All these files are read from the `$CAMBIN/../admin/` directory, where `CAMBIN` depends on the GEIRS version selected when GEIRS is started. This implies that their contents is maintained in the SVN repository and new contents should be fed back into the repository not to be lost.

7.1.1 wheel*

The wheel indices are in the order as the light beam hits them, `wheel0.panic` denotes the cold stop, and `wheel[1-4].panic` are the filter wheels before the final lens and detector.

Each file starts with a "fixed" block and is followed by an optional parameter block.

Fixed block Each line of the "fixed" block starts with one or two parameter strings optionally followed by a comment after a `#`.

The names of the positions in each of the wheels are starting in line 6 of the file of the individual wheel, `wheel0.panic`, `wheel1.panic` etc. (Warning: the enumeration of the top block of lines in these files is absolute, which means lines that are empty or contain only comments will confuse the parser of these files.)

1. The first line of the fixed block is the name of the wheel.
2. The second line of the fixed block is a type of the wheel, either `APER` or `FILTER` or `OTHER` or `OPTICS`.
3. The third line of the fixed block is the number of positions for a full turn of the wheel. No longer used.[24]
4. The fourth line is a number of backlash steps. If the number is positive, the named positions are reached by approaching them from lower positions (in step units); if the number is negative, the named positions are reached by approaching them from higher positions (in step units). If the current motor position is on the "wrong" side of the target position, reaching the new target is split into two phases with a halt on the "correct" side of the target position such that the second phase approaches the target position from the side indicated by the sign of the backlash.

   The backlash is not applied while moving to the home position. Setting the backlash to zero steps means that the target position is reached in one phase. In summary, using a nonzero value ensures that the filter position is always reached from the same side—at the expense of slightly longer durations on the average.

[24] The current software reads the positions starting at line 6 of the fixed block.

5. The fifth line is the number of named positions to follow. Two times that number actually defines the distance to the end of the fixed block, because each position requires two further lines in the fixed block.
6. The sixth line up to the end of the fixed block contain pairs of lines. The first line in a pair is the name of the element. The second line in a pair is (i) an index (counting upwards from 1) of the element followed by white space and (ii) an integer number that indicates the position of that element in units of MoCon steps, relative to the home position.

Parameter block Each line of the parameter block is either just a keyword (flag) or a parameter name followed immediatly by an equal sign and a number. The order of parameters and flags in the parameter block does not matter.

- DISABLE sets a flag which indicates that the motor should not be moved.
- PDRIVE is a parameter ≥ 1 which provides the MoCon drive number of that wheel
- TOUT is a parameter which specifies a time out in units of seconds.
- SPECIALDRIVE is a flag to indicate that the home position is mapped on bits 12 and 13 of the MoCon's 197 command. For PANIC this is exactly to be used for the cold stop mask wheel.
- CHKFOCUS indicates that the element's optical thickness (taken from the `elements` file) is taken into account while computing the telescope focus offset.
- GEARRATIO is the ratio of the number of turns of the motor axis to the number of turns of the wheel axis. For PANIC two different values appear; the parameter for the cold stop wheel is larger by a factor of 88.

Some parameters that are used to initialize the MoCon firmware [22] are configurable:

- BS_VELOCITY is the "basic setting" of the motor's velocity
- BS_ACCELERATION is the "basic setting" of the motor's acceleration and decelaration.
- BS_STEPS is the "basic setting" of the number of steps of the motor for a full turn of the motor axis. The product of GEARRATIO and BS_STEPS is the number of motor steps for a full turn of the filter/wheel axis.
- MS_HOME_VELOCITY is the motor velocity while searching for the home position.
- MS_DOCKING_VELOCITY is the motor velocity while zooming backwards to the home position
- MS_DOCKING_DISTANCE is the distance of traveling further than the home switch after hitting it first and before inverting the direction

Velocities are in units of revolutions per minute. Accelerations are in units of revolutions per minute squared.

To change the name of a filter element, the change must be executed at the same time in `wheel`w`.panic`, in the `elements.panic` and everywhere in the associated column of the w-th wheel in `fmacros.panic`.

7.1.2 fmacros

Filter (motion) macros are defined in the `$CAMBIN/../admin/fmacros.panic` file by inventing a synoptic name of the macro in each first colum of the file and listing in left-to-right order for wheel0 to wheel4 the names of positions of the wheels for that configuration in the same line. There is a symbolic link to that file in `$CAMINFO` to support the OT which looks only into that fixed directory for macro names.

Syntax: In the `fmacros` file, comments are started with either the semicolon (;) or with the sharp (#) and extend to the rest of the line in which they occur. Empty lines are ignored. In each line, a name (label) characterizing the compound filter set and the individual wheel positions are separated by any amount of white space (blanks). If there are more names than wheels in the instrument, the trailing names are ignored.

Each position refers to a name in `$CAMBIN/../admin/elements.instr` and to a name in a file `$CAMBIN/../admin/wheel[0-].instr`, a set of files that enumerate wheels enumerated from index 0, again with the instrument's name (.panic) as the suffix. The dash (-) or the star (*) in a position in a line of the `$CAMBIN/../admin/fmacros.panic` means that the macro should not move the wheel, wherever it currently is. Dashes are currently used for all macro lines at the position of wheel0, the cold stop wheel.

7.1.3 elements

Properties of each named position of a wheel are defined in `$CAMBIN/../admin/elements.panic`. After the name, there are only three properties configured for now, separated by white space:

1. a sort of manufacturer's ID. This string is not actually used anywhere in the software.
2. a detector focus offset to be uploaded to the telescope focus for compensation of the OPD if that element is in the beam and the 2.2m telescope was selected at startup. The total optical path is calculated as the sum of these compensations before the motion and after the motion of the filters. If these two path differences differ (and focus correction is activated), GEIRS sends the difference via the `tele focus` command to the telescope.

   The total OPD is calculated only over the set of wheels for which the `CHKFOCUS` property is set (i.e., not in a comment line) in their `wheel*.panic` file. The requested focus adaptation is compared with the value returned by the telescope; if both differ by more than 0.002 mm, a warning is issued. This warning may pop up a GUI unless the motor GUI's are silenced with the `wheel dialog off` command.
3. a detector focus offset to be uploaded to the telescope focus with the same functionality if the 3.5m telescope was selected.

If the name of an element occurs more than once in the `elements.panic` file, GEIRS effectively uses the first "hit" while searching through the file from above. If the actually installed element is the second, for example, one might simply put the first of the lines in a comment to let GEIRS skip it.

7.2 PANIC Specific

One turn of the filter wheel is equivalent to $200 \times 563/42 = 2680.952$ steps of the motor controller; that is 7.44709 steps per degree.

A full turn of the cold stop wheel is equivalent to $200 \times 88 \times 563/42 = 235923.8$ steps. The difference in the two positions for the 2.5 and 3.5 m telescopes is half a turn, 117961.9 steps.

These ratios are relevant from the operator's point of view if the `wheel ... relative ...` variant of moving wheels is used (see Section 5.3), because the last number as the argument to that command is in units of motor steps.

The 6 positions of the filters on each axle are roughly equidistantly spaced by 60°. To replace a filter, an intermediate position is needed at an approximate angle of 97.5° (or 726 steps) away from its in-beam location; 97.5° cw looking with the beam onto the filters, 97.5° ccw looking from the detector onto the filters. The other 3 wheels need to move one of their `Open` positions to the same angle. Because these filter exchange positions have not been included as named positions in the `wheel[1-4].panic` files, this `wheel` command with the `relative` argument is the dedicated way to move the filter wheels to these positions.

7.3 Concurrent Telescope Moves

The general configuration of motor parameters leads to telescope offset commands after the motor's individual or macro motions are finished—depending on the combination of `CHKFOCUS` flags (Section 7.1.1) and focus offset sums (Section 7.1.3) of the wheels that were moved.

The consequence is that in practise a `wheel` command should be followed by both a `sync wheel` and a `sync tele` (or just a `sync`).

8 EXPOSURE TIME

8.1 Nomenclature

The expected time that expires between the `start` command and the receipt of the last pixel values of the last frame is of interest to exposure time calculators. It is a function of readout mode parameters and is estimated by the formulas summarized below.

The overhead of (i) additional computations if the frames are to be averaged/integrated with special options of the `save` command and the overhead of (ii) actually writing the FITS frames to disk is not included here. These are functions of number and types of CPUs and disk speeds of the computer on which GEIRS is run, and depend also on any post-processing tasks added to the `QueueFiles` like the first state of the pipeline [14] .

The number of frames still to be read may be monitored by sending the `status frame read` to the server, which responds by counting upwards as a function of time. This is equivalent to looking at the numbers that appear at the `Read` label in Figure 6 which turns yellow after the `start` is received. The two dominant parameters are the repeat factor (which is available by sending `status crep`) and the cycle time (which is available by sending `status ctime`). For any supervisor script it is much easier to deduce the real time of exposures by taking the cycle time as the base unit than taking the integration time, because the influence of parameters like `EMSAMP`, `PREAD`, `PSKIP`, the pair count of the multi-correlated (Fowler-type) samplings, and any form of hardware windowing (first type in Section 5.6.1) has already been incorporated then. The composition of the cycle time by interlaced execution of resets, reads, and idle waits is described elsewhere (see Section 1.2).

Note that the precision of this prediction is generally not better than the cycle time for all modes that use (or are coupled with) the ROE idle mode named `wait`. The reason is basic and simple: the `start` command is generally not synchronized with the idle cycles of the detector readout. The first pixel read waits (as the name says) for the end of the present idle cycle. (The need to read the detector even if no data are emitted by the electronics is a fundamental aspect of infrared detector exposure management and not discussed in this software manual.) The mean value of the time is the value expected for the `break` idle mode plus half of the cycle time. (One can mitigate this effect by adding a sort of dummy `sfr` exposure with minimum short integration time at the end of all long exposures—which will be adjusted upwards by GEIRS to the shortest manageable value—. The next exposure will then find the detector in a short cycle mode and react with predictable latency. The associated waste of disk space and overhead time can be kept low by saving these with the `-d` option.)

The formulas below contain small fudge factors that have been obtained by fitting a small number of exposures. They realize some overhead caused by the data transfer chain from the ROE via DMA control to the GEIRS buffers on the server.

8.2 Lir with idle break

If the readout mode is `line.interlaced.read` with idle mode `break` the time is

$$t[\text{sec}] \approx 0.3 \times N_f + t_{\text{cyc}}[\text{sec}] \times N_f \qquad (8)$$

where the number of frames N_f has been set by the application with the `crep` command and where t_{cyc} is the cycle time.

8.3 frr with idle break

If the readout mode is `fast-reset-read.read` with idle mode `break` the time is

$$t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.03 \times N_f. \tag{9}$$

8.4 mer with idle break

If the readout mode is `multiple.endpoints` with idle mode `break` the time is

$$t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.003 \times t_{\text{cyc}}[\text{sec}] + 0.005 \times N_f. \tag{10}$$

There is no explicit dependence on the `CPAR1` parameter (number of Fowler pairs) which is already incorporated in the cycle time.

8.5 sfr with idle break

If the readout mode is `single.frame.read` with idle mode `break` the time is

$$t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.06 \times N_f. \tag{11}$$

8.6 Hardware Windowing

The action of hardware windowing (Section 5.6.1) skips line set blocks along the "slow" readout direction of each of the detector chips. The slow direction is parallel to the stripes of the 32 readout channels. For Hawaii2 RG chips run with an odd `CAM_DETROT90` parameter (LUCI, CARMENES), the slow direction is left-right in the images. For Hawaii2 RG chips run with an even `CAM_DETROT90` parameter (PANIC), the slow direction is up-down. For Hawaii2 chips (LN) the slow direction depends in which of the four quadrants the subwindow is placed.[25]

Neglecting details, the time is shortened proportional to the number of pixels that are not fed into the 32 ADC's, because the conversion takes the lion's share of the readout time. An estimate of the maximum speedup (and associated shortest integration time) relative to the full-frame readout is obtained by projecting all hardware windows (on a per-chip basis for the Hawaii2 RG and per-quadrant basis for the Hawaii2) as "shadows" onto their slow directions, which defines a set of one-dimensional pixel intervals (overlaps merged where occurring). Due to the back-to-back mounts of Hawaii2 RG's for PANIC and CARMENES, the orientation of interval must be chosen different for half of the chips, from a corner of the mosaic into the direction of the midpoint of an edge of the mosaic.

The total number of pixels in that set of intervals relative to 2048 is the relative speedup and reduction in integration time that can be achieved. This is not proportional to the ratio of the pixel-sum in the windows over the pixel-sum in any of the detectors, put proportional to some kind of edge-length sum along the slow readout direction.

The GUI in Figure 6 can be used as a pocket calculator for these times. Once the subwindow is defined and enabled, so the associated two `Subwins` buttons are green, one can enter an integration time of zero into the `IT`; GEIRS sums up the pixel clocks in its patterns according to the selected

[25]The `subwin auto on` command dissects windows that cross chip or quadrant boundaries so the observer does not need to be fully aware of details.

readout mode, and inserts this minimum time back into the GUI. (This works also in simulation mode.)

A numerical example for the Hawaii2 4-quadrant case of LN: If the width of an isolated window is increased by one pixel along the slow direction, the total number of pixels read out increases by $4 \times 1 \times 1024$. The number of pixels channeled through a single ADC increases by $4 \times 1 \times 1024/32 = 128$. At a pace of the (standard) pixel read time of 10,000 ns (`prd` time in Figure 6), the increase in time is 128×10 ms $= 0.00013$ s. This number is for a single read; for an `lir` double read this becomes 0.0025 s (which will usually be announced in the controls GUI of Figure 6 as twice as that as long as the repetition factor is kept at 1 because the group of the first read-reset-read and the second read-reset-read is added all up).

A more detailed timing analysis of the most recently enabled pattern is kept in `$CAMTMP/timing_-cmds.log`, and `status subwin` shows some of the window geometries that are involved [5]. A coarser measured timing of frame arrival times on the workstation is found in the `EOFRM` keywords in the FITS headers.

As a practical result of this analysis, one does not "loose" time if windows are stretched along their maximum extension along the fast direction. So for LUCI an assignment of the format

`subwin SW` $i\ x\ y\ w\ h$

can always be replaced by

`subwin SW` $i\ x$ `1` w `2048`

expanding the window up-down. For PANIC, the assignment can be replaced by

`subwin SW` i `1` y `4096` h

expanding the window right-left over both detectors. This will keep the integration times almost constant, but lead to larger detector regions in the FITS files.

8.7 Higher resolutions

The fact that the MPIA electronics reads 32 channels of 4 quadrants of the Hawaii-2 detector chip in parallel leads to a characteristic pattern of 32 time ramps of pixel reads across the detector. Figure 36 illustrates for a single full-frame reset-read at which time the individual pixels are reset and read. The first 32 pixels are read at time 0; the last pixels are read at time $2048^2/32 = 131,072$, which is scales to ≈ 1.4 seconds—half of (1)—for the standard `PSKIP`, `LSKIP` etc. parameters.

For Hawaii-2 RG detectors (not relevant to LN) there are not 32 ramps in quadrants but 32 ramps with tops and valleys stretching over each chip. Otherwise the time scales are the same as above, because the number of channels per chip, the number of pixels per chip, the pixel read base times and ADC conversion times are the same as for the Hawaii-2 types.

For all relevant readout modes, the times of the pixel reset and the times of their readout are coordinated such that both have the same type of "offset" on absolute time scales [6]. In consequence,

- the differences (the exposure time) between reset and readout are constant across all pixels and all detector chips (with the exception of the reset windows in the `srre` mode);
- the mean (center) time of the photon flux has the same, predictable offset as a function of pixel location in the detector.

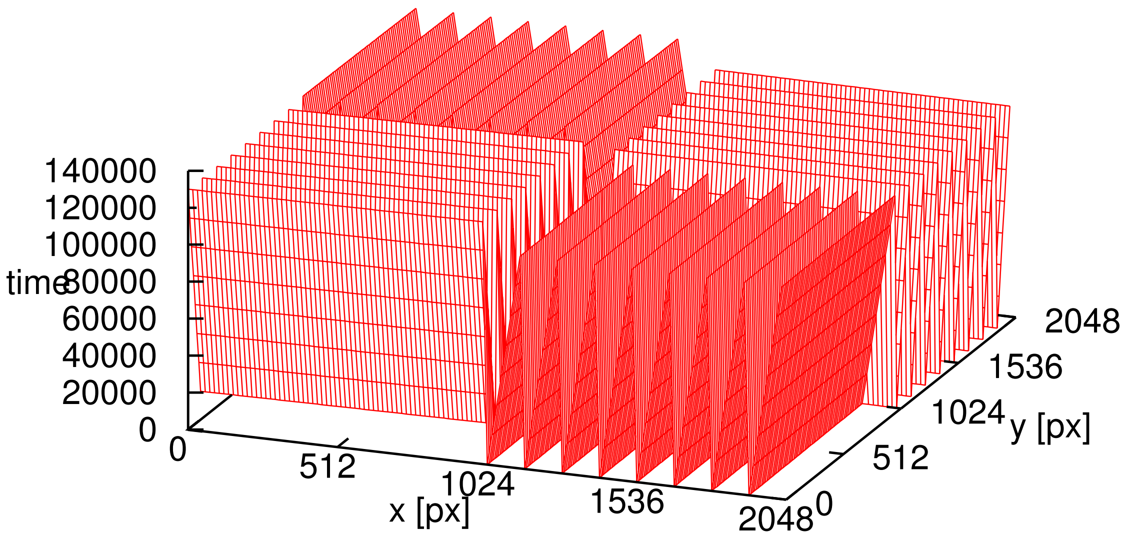


Figure 36: Pattern/distribution of effective pixel time as a function of Hawaii-2 pixel position. The transformation of the two axes directions to the FITS and image coordinates depends on the currently active `CAM_DETROT90` and `CAM_DETXYFLIP` parameters (Section 3.2).

Note that if hardware subwindowing is used, these time axes can be squeezed considerably and become a more complicated function of placement and size of the windows on the chips. (If instead the windows are only established by slicing the images by software on the GEIRS computer, the pixel timing is the same as for the full-frame readout. This way of obtaining the information in windows by pure software postprocessing is not much relevant in practise.)

To visualise the timing across the detector chips one may actually take an exposure in the single frame read mode (sfr) under rather strong illumination with the default (=shortest) exposure time. Because this readout mode resets all chips of the detector at (almost) the same time and then starts reading the pixels in their "channeled" order, the actual exposure time is zero for the pixels read out early and longest for the pixels read out last. Just looking at the FITS image at sufficient contrast then displays "bars" of brightness variations along each readout channel.

8.8 Bright Sources

If the illumination on the detector is faint, the fundamental means to adjust to the basially fixed detector gain is prolongation of the integration time. If on the contrary the illumination on the detector is too strong, there is only a limited set of tools to avoid detector saturation and the associated memory/persistence effects—because the minimum integration time is rigidly limited by the fixed number of channels that are read in parallel and by the maximum 1 MHz speed of ADC conversions—. From the point of view of the GEIRS control model, these are the prospective tuning parameters:

1. Roughly a factor of 2 in speed is available by clocking faster, which means decreasing the default pixel read time (typically 10,000 ns) by roughly a factor of 2, see the `prd` button in

Figure 6 and the `ptime` command in section 5.3. This implies that electronic multi-sampling is not used (see the `roe` command).

2. Skipping pixel lines in the slow direction by hardware windowing (Section 8.6) offers speedup factors of the order of 10 or 30 depending on how much coverage of the detector is needed.

3. Roughly a factor of 2 is gained if not the `lir` mode with two reads per scan but only a mode with one read per scan is used, for example the `srr` with only two reads in total. If relative photometry across the detector is not important but only identification of positions on the detector, one might consider the `sfr` mode which has the advantage of a full-frame reset (avoiding saturation in all areas of the detector) but reads all pixels only once.

4. The voltage of the external bias may be increased (Section 9.1).

5. Taking an idle mode with the most frequent resets is also advantageous to avoid persistence effects (button in Figure 6 and the `idlemode` command). Note that for a `srr` mode with two reads the `ReadWoConv` may be faster than the default `Lir` idle mode, because the associated cycle time may be slower if the integration times are short anyway. The `Reset` idle mode is the fastest one offered.

6. If the saturating regions on the detector are a few, and the problem at hand is rather a problem of large contrast through the areal regions, some detector types and instruments offer to mask these (i.e., reset them frequently) with the `srre` mode (Section 5.6.2).

9 TROUBLE-SHOOTING

9.1 ROE Interface

1. Problem: No data appear and the main screen of Figure 15 remains black. GEIRS emits errors of the sort that `init` returns error codes equivalent to timeouts while trying to connect to the camera. Check list: First check that the rack of the readout electronics is powered on. Then ensure that the shell variable `CAMPORT` (Section 3.2) in the `scripts/GENERIC` is correct, including the `TCP` marker and the port number, that the readout electronics has actually been set up to listen to that address [3], and that a `ping` command with that (numerical) address from the GEIRS computer gets an answer from the readout electronics.

   ```
   ping 192.168.90.20
   ```

   If messages of the sort

   ```
   INFO MPIA-ROE3 reset - '33 8 0 1'
   INFO Seen ROE3 rocon 'DETFPGA' version '3 1 7 5'
   INFO Seen ROE3 rocon 'ADCFPGA' version '3 0 2 2'
   ```

   appear when GEIRS is started up, the network interface between the host computer and the ROE is working.[26]

   For instruments with single chips (LN, LUCI) check that the two fiber heads have not been swapped on the OPTPCI side where they enter the workstation (or to the same effect, on the ROE side where they enter the ROE rack). If the fiber connection is disrupted, messages of the

   ```
   (E_ptimeout=21) timeout on OPTPCI interface
   ```

   kind appear in the GEIRS logs because GEIRS waits longer than expected for the video data. For CARMENES, swapping fibers leads to a right-left swap of the two detector pairs (i.e., exchange of pair images in the display and in the FITS files). The OPTPCI board offers plugs for two fiber pairs on the rear side of the workstation that receives the detector data. The basic industrial application of this type of hardware/connector is bi-directional network data transfer, but the MPIA ROE uses them only for one-way detector image data transport of the 16-bit data from the ROE into the workstation, so two of the plugs are never used and usually covered by some dust cover (Figure 37) [23]. Effectively a single fiber pair connects an ROE and an OPTPCI at the workstation. Both fiber cores are used for data transfer for PANIC and CARMENES, but only one core for data transfer for LN and LUCI. Because the equivalent selection of plugs is to be made on the ROE side, this gives a probably of 3/4 for LN and LUCI to get no data and a probably of 1/2 for PANIC and CARMENES to get swapped images if fibers are plugged in at random.

   Ensure that the OPTPCI driver is compiled and installed (`lsmod` as in Section 2.1.1).

   Run any of the tests in the appendix of the pattern manual [5] to ensure that data from that board's data generator generate stripes in the GEIRS display.

   If more than one OPTPCI is plugged into the computer, check the correct `DATAINPORT1`/`DATAINPORT2` setup in `scripts/GENERIC`, otherwise make sure this is the `/dev/plx-00`/`/dev/plx-01` pair.[27]

[26] Unfortunately starting GEIRS with the Java GUI Figure 5 never generates output on the Linux standard output, so that test is not available if that method of starting is used.

[27] This is currently the case on one of the two LUCI computers at the LBT and on `elablx01` and `irws2` at the MPIA.

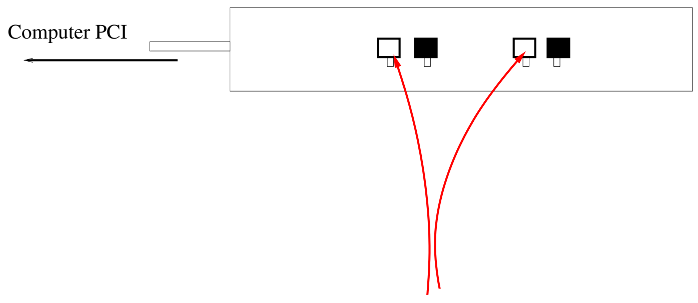


Figure 37: Fiber connectors of the OPTPCI board on the rear side of the workstation. Note that depending on which riser board is used on the computer, the entire figure might look rotated relative to this diagram.

2. Problem: GEIRS says

   ```
   ERROR (91) opening line: '(E_camline=91)'
   ```

   Solution: GEIRS cannot open a socket via the Internet to the readout electronics. This indicates errors as already discussed above. Either the ROE is not powered on, or the GEIRS configuration of the `CAMPORT` (in the `GENERIC` startup script) does not match the ROE's actual IP. For debugging note that GEIRS displays the current value at startup with a line of the format

   ```
   Setting ROE port to tcp://192.168.3.xxx:4000
   ```

   on the Linux shell and also in the `RO-Electronic` field of the GUI in Figure 4. For a quick temporary check whether the IP address is the culprit, one can either use the engineering GUI in Figure 5, or set the environment variable `CAMPORT` *before* starting GEIRS (because, as mentioned in Section 3.2, the startup script does not override an existing value).

3. Problem: The cycle time stays at zero seconds in the GUI. Potential causes:

   (a) The pattern files in the directory `GEIRS/INFO/`*instrument*, where *instrument* is `Carmenes` here, have not been installed correctly (Section 2.2), or the value of the environment variable `CAMINFO` (Sec. 3.2) defined in the `scripts/GENERIC` file points to a wrong or non-existing directory.

   (b) GEIRS never got the `init camera` command (Section 5.3). This command is actually submitted by clicking `all` or `OK` in the startup GUI, Figure 4. However, if the two main processes (`shmmanager` and `cmdServer`) and/or the other processes (`control`, `disp`) are called directly from the UNIX/Linux command line without using this interface, the command may not have been issued. This can be submitted for example with the `Re-init ROElec` submenue of Figure 6.

   (c) The internet connection to the ROE does not work (see above). Occasionally this is caused by temporary congestion (and the error log monitor will display timeouts) and sending the patterns again to the ROE—with the `Re-init ROElec` button of Figure 6 or the `init camera` command of Section 5.3—will remove the problem.

   (d) GEIRS was not started in simulation mode but the ROE does not respond—for any of the reasons described in Section 9.1.

   (e) The `rotype` has been set to `dgen` (the OPTPCI data generator). Execute

   ```
   status rotype
   ```

in the GEIRS shell to see whether this is the case and set it back with

```
rotype plx
```

4. Problem: The detector images appear to be basically flat zeros, because the raw single frames (prior to the subtraction) are highly saturated near the maximum of 65,535 counts. Solution: This has been observed if the CARMENES detector is operated at rather warm or ambient temperatures. This can be improved by rising the external bias voltage applied to the chip(s) from the default value ($\approx$ 2.2 V) to values near 2.5 or 2.6 V. The value would be altered with the `bias` command (Section 5.3) in the style of

   ```
   bias det1 extbias -V 2.55
   bias det2 extbias -V 2.55
   ```

   The same effect has been observed with the LN detector after cooling down the entire optics and just switching on the ROE, which improved slowly afterwards when the ROE was switched on[28]. In this case one could lower temporarily the external bias to a value near 1 Volt for a first visual check of the LN detector image:

   ```
   bias det1 extbias -V 1.0
   ```

   The voltages remain until they are either overwritten with another `bias` command or until GEIRS resets the detector or is restarted. The current value is revealed by the command

   ```
   bias
   ```

5. Error messages of the form

   ```
    libplxmpia.c:233: [plx_find_device] ERROR)  Error in Plx device found (u=2/chan=0): ff
   ```

   or

   ```
   ERROR Error: plx_find_device: 'PLX ApiError 516 - ApiNoActiveDriver'
   ```

   mean that the driver for the board that interfaces with the RoCon fiber optics has died or not been installed. This is usually fixed at boot time—as in Section 2.1.1—or by executing

   ```
   cd $CAMHOME/scripts
   sudo plxstartup
   ```

6. Problem: Error messages of the form `unable to allocate Memory for Buffer...` appear and no frames are read. Workaround: This indicates that the driver is not capable of allocating the kernel memory for the next exposure. The only known solution is to shut down GEIRS and to reboot the computer. This basically manifests a kernel memory leak that can be caused for example if some killed the `geirs_rdbase` process from the operating system while is uses kernel buffers for reading (i.e., while a `read` command is active). The advice is to use only the standard tools for shuting down GEIRS as documented in this manual.

7. Problem: Communication with the ROE times out with messages like `ERROR 23 Command 'ctype srr 4' returned errorcode = 23:  (E_ctimeout=23) timeout from camera (control line)`. This is occasionally caused by very high traffic in the network. The associated timeout is set to 5 seconds generally and to 10 seconds at the MPIA network in `camsend.h` and can be increased (followed by recompilation with `make install`) if this is a permanent problem.

[28]which warms up the pre-amplifiers that have some minimum operating temperature

9.2 Software

1. Problem: An attempt to start GEIRS does not open the GUI of Figure 4, but instead it just shows some process list of the operating system with processes like `geirs_shmmanager`, `geirs_cmdServer` and says that some `shmsocket` exists. There is some output that says `cannot attach info page`.

   Solution: This means that GEIRS is alread/still running, which means you or someone else with access to the user account has started it and did not shut it down. Ring up all people in that user class and ask them whether they are still operating the readout electronics, and figure out with

   ```
   tail ~/GEIRS/debug*.log
   ```

   when the last action of this session took place. If you are absolutely sure that there is no harm done by forcing that application to quit, you may call `geirs_cleanup` to kill that GEIRS application and then try again to start it.

2. From time to time it can happen that a process hangs. Mostly you can simply kill the hanging process. Some commands are prepared for this, as documented in the command list (Section 5.3):

   - `kill read` terminates a read command
   - `kill telescope` terminates any command to the telescope
   - `kill wheel` terminates any command for the filter wheels

   Type these commands in the interpreter window where you have started the GUI, not into the UNIX/Linux shell (where it refers to processes of the operating system).

3. GEIRS does not start, and some logs with the operator's name and some process names appear. Solution: the previous GEIRS session was not closed and remains active under the same Unix account. Run `geirs_cleanup -a`, then `ps -u $USER | fgrep geirs` to ensure all GEIRS processes have died, and restart again.

   It seems that this situation may arise if some process send a command to the GEIRS shell and terminated or was killed before it received the answer.

4. Problem: The GUI does not open, and there is a message like `can't allocate info page`. Solution: Type `geirs_cleanup -a` before you start the GUI. This program deletes shared memory pages left over by the same Linux/Unix user from a previous session and shared memory sockets `tmp/shmsocket`. The underlying problem is often that GEIRS was not properly shutdown, for example because the computer rebooted due to power failures. On some computers running openSUSE 13.2 this rebooting happens when sleep (suspend to RAM) does not wake up as intended.

5. Problem: Anything seems to work well but there are no stars. Solution: Check the `Last` button in the display window Figure 15 back to green so the images are updated.

6. Problem: The GUI in Figure 6 and the associated commands `crep` and `ctype` accept only small numbers; the GUI sets values back to smaller ones, and the status shown by the commands (without parameters) also shows smaller counts than requested. Solution: Increase the `CAMSHMSZ` parameter in `scripts/GENERIC` (section 3.2) and/or the limit set by the operating system (section 2.6.4) before starting GEIRS.

7. Problem: At startup time a message of the form `ERROR opening file ... GEIRS/INFO/...` appears. Solution: Install the pattern directory (Section 2.2). Ensure that the GEIRS user has read access on these files. Check that the value of the environment variable `CAMROE_REV` (if set, Section 3.2) names one of these existing directories.
8. Problem: When `save`ing, a FITS filename and a message of the form `save: (E_fopen=48) could not open file` appear. Solution: Either
   - the disk is full (tested with `df -h`) or
   - the GEIRS user does not have write permission on the current data directory. This is revealed for example if one attempts to create an empty dummy test file in the style of `touch junk.txt` in that directory. A workaround then is to create a new directory with the `SavePath` button of Figure 6 for future use, which will by default be created with the corresponding write+executable permissions, or to use `mkdir` of the Linux shell in conjunction with a `set savepath` of the GEIRS shell, or to obtain modifying privileges of the intended data directory and execute `chmod g+wx` on this if owned by another user.

   Keep in mind that GEIRS does not overwrite existing FITS files (with the exception of those created via the `sfdump` command or if explicitly permitted via the `clobber` command or with the `-c` of the `save` command). This is important if operators set explicit file names with each `save` command instead of relying on the automated file selection.
9. Problem: the `ctype srre` responds with an error of the format `ERROR Too large tblindex 256 of max. 256 in dettable=2`. Solution: reduce the number of reset windows defined in the configuration file. The current limit is near 80 windows on each individual detector chip.
10. Problem: `geirs_cleanup` responds with a message of the from `If ‘cleanup‘ is not a typo...`. Solution: expand the `PATH` variable as described in Section 2.6.2.
11. Problem: After the read process finished the `save` button in the controls GUI in Figure 6 stays yellow. Solution: This happens for example if automated save processes fail due to a disk full state. This is in particular a thread on the CARMENES computer with only 180 GB of disk where single frames saving with the `sfdump` interface is on by default. (This is equivalent to less than 4 hours observing time at a maximum speed of 1 frame each 1.3 seconds.)
12. Problem: The single frame dumps of CARMENES seem to miss some frames in `LIR` mode. Solution: Operate GEIRS in accordance with standard parameter ranges. In detail:
    - Avoid disk full states.
    - Do not abort the reads in correlated double sampling modes before the second frame is read. The first stage pipeline will reject processing output of that kind with error messages.
    - Do not impose heavy disk I/O loads besides GEIRS's own automated guide mode dumps unless you are sure that your disk writing speed exceeds the throughput of the 16 MB per frame by at least a factor or two. GEIRS may drop single frame dumps if it cannot keep up with the frame rate.[29]
    - Avoid `crep` parameters larger than one in conjunction with the `ctype lir`. This will generate the raw frames but the first stage pipeline (and further processing) will discard any images put the last one.

[29]This is a deliberate design choice to support smooth processing with the first stage pipeline.

- Because the FITS name convention for CARMENES uses time stamps rounded to full seconds, GEIRS starts to drop frames if the frame frequency becomes larger than one frame per second. This happens for example if subwindowing is used or the pixel read time is reduced. To store all frames anyway, use an explicit `save` with the single frame option (although these will not be recognized by the first stage pipeline).

13. Problem: Macros with `crep 30` and `ctype srr 45` miss frames with CARMENES. GEIRS stores only 33 instead of 45 frames. Solution: The RAM requirement for the frames would be $30 \times 45 \times 16$ MB, which is larger than then 16 GB of (half of the total RAM) on the NIR computer, see Section 2.6.4 and the `CAMSHMSZ` parameter in Section 3.2. Make sure that the arithmetic product of the repetition value by the number of frames along the ramp is less than 1000; if needed split exposures into multiple `read`s to stay below that limit for each single `read`.

9.3 Operating System

1. Problem: After `start* -gui` time GEIRS complains that `DISPLAY` is not set.[30] Solution: For all steps of establishing tunnels and using `ssh` to login to the GEIRS workstation, use the `-X` option as documented `ssh(1)`.

   In addition, if commands are run through a `sudo`,

   - the `env_keep` list of variables in `/etc/sudoers` ought include the `DISPLAY` variable to forward the variable from the user who runs the `sudo` to the effective user after the `sudo`.
   - the effective new user needs to be authenticated with the information of (basically) `.Xdefaults` of the user who runs `sudo`, see [9].

2. Problem: the startup scripts prints some dots and then says `Cannot connect to shmmanager`. Solution: The shared memory allowances set in Section 2.5.1 are too small, so the shared memory manager does not start.

3. Problem: the command `geirs_cleanup` is not found. Solution: Add `$CAMHOME/scripts` to the shell as described in Section 2.6.2.

4. Problem: GEIRS fails to open its GUIs claiming that it cannot allocate its color maps. Solution: close some of the other graphics intense programs that are currently running on the same display and/or invest into contemporate hardware.

9.4 External Software

(Of course, these things have nothing to do with GEIRS.)

1. If `fv` displays in `pow` a transparent image, the `kde4` allows to change this behavior by either `<Shift><Alt><F12>` momentarily, or by disabling these effects in the Application Launcher Menu in `Personal Settings (Configure Desktop)` → `Workspace Appearance and Behavior` → `Desktop Effects` and unchecking `Enable desktop effects at startup`.

2. If the `start_geirs` call does not open the GUI 5 but emits errors complaining on missing AWT related libraries, the `gcj` has been incompletely configured, probably the `--enable-java-awt`

[30] Of course this has nothing to do with GEIRS.

switch of the configuration of the `gcc` bundle was missing, see Recompile gcc under openSUSE 11.1 for details. This may potentially be cured by installing the associated java developer packages which are not enabled by default in openSUSE installation managers.

A BEYOND GEIRS

This section adds information on processes, other programs or aspects of the operating system that are not under GEIRS control nor part of the source distributed by the MPIA.

A.1 Installment of a new ROE IP address

How to change the IP address of the MPIA ReadOutElectronics[31]

A.1.1 Using RS232

Uninstall the ROCon board and set the configuration DIP switches 5 and 7 to ON. Start a terminal program like `PuTTY`. Reinstall ROCon board and connect it to your computer using a null modem cable. The serial settings are: 9600N81. Power on ReadOutEelctronics. You should see a message like this:

```
33 6 0 4 COS_XC161 V2.16, Jul 11 2007
33 6 0 4 ReadOut Controller V3.00beta, Jan 10 2013
33 6 0 4 System ready...
```

Now set the IP address (192.168.3.160 for example):

```
33 30 0 192 168 3 160
```

Note that there are blanks instead of dots separating the four numbers of the IP address. The new address can be read back after a soft reset (33 8 0), a pushbutton reset or a power on reset:

```
33 31 0
```

The ROCon boards responds:

```
33 31 0 2 192.168.3.160
33 31 0 1
```

If necessary the subnet mask can be set with:

```
33 34 0 255 255 255 0
```

The Subnet mask can be read back after a reset(see above):

```
33 35 0
```

Don't forget to set switch 5 to OFF for regular operation with new IP address.

[31]Contribution by U. Mall, 29 Feb 2015

A.1.2 Using ethernet

In case of configuring via ethernet your computers network adapter has to have an IP address in the same subnet as the ReadOutElectronics. Then you can `telnet` the ReadOutElectronics on port 4000:

```
>telnet 192.168.3.167 4000
Trying 192.168.3.167...
Connected to 192.168.3.167.
Escape character is '^]'.
```

The ROCon board responds with a message like this:

```
33 6 0 4 COS_XC161 V2.16, Jul 11 2007
33 6 0 4 ReadOut Controller V3.00beta, Jan 10 2013
33 6 0 4 System ready...
```

The next step is to login and reserve a module number:

```
33 21 0 user
33 22 0 mpia
33 23 0
```

For every command the ROCon board sends acknowledge:

```
33 21 0 1
33 22 0 1
33 23 0 1
```

Now setup new IP address (192.168.3.160 for example):

```
33 30 0 192 168 3 160
```

Note that there are blanks instead of dots seperating the four numbers of the IP address. The new IP address is activated after a soft reset(33 8 0), a pushbutton reset or a power on reset. After reset your telnet connection is lost. Ensure that your computers network adapter is in the same subnet as the new IP address and reconnect:

```
>telnet 192.168.3.160 4000
Trying 192.168.3.160...
Connected to 192.168.3.160.
Escape character is '^]'.
```

If you have done everything right you will see this message:

```
33 6 0 4 COS_XC161 V2.16, Jul 11 2007
33 6 0 4 ReadOut Controller V3.00beta, Jan 10 2013
33 6 0 4 System ready...
```

If necessary the subnet mask can be set with:

```
33 34 0 255 255 255 0
```

The Subnet mask can be read back after a reset(see above):

```
33 35 0
```

A.2 Image Rotation

The two configuration parameters `CAM_DETROT90`= r and `CAM_DETXYFLIP`= f specify an image transformation (r, f) defined by a rotation by a multiple of 90° ($r = 0, 1, 2, 3$) followed by an optional image flip of $f = 0$ (none), $f = 1$ (right-left) or $f = 2$ (up-down).

The four choices for `CAM_DETROT90` combined with the three choices for `CAM_DETXYFLIP` supply $4 \times 3 = 12$ combinations. This is only half of the $4! = 24$ possible permutations of all 4 corners, because only one of the orders of the two operations is implemented/supported. A closer look shows that each of the rotations followed by a right-left flip can be replaced by a rotation through another 180° and a up-down flip: $(3, 2) = (1, 1)$, $(2, 2) = (0, 1)$, $(1, 2) = (3, 1)$, and $(0, 2) = (2, 1)$. So there are not 12 but only 8 image operations available. Those of the 24 that appear to be missing are group operations which would try to generate images where North and South remain not opposite to each other but end up at right angles. The transformation (r, f) is an element of a non-abelian group of order 8. The group multiplication table is shown in Table 1.

	(0,0)	(1,0)	(2,0)	(3,0)	(0,1)	(1,1)	(0,2)	(1,2)
(0,0)	(0,0)	(1,0)	(2,0)	(3,0)	(0,1)	(1,1)	(0,2)	(1,2)
(1,0)	(1,0)	(2,0)	(3,0)	(0,0)	(1,1)	(0,2)	(1,2)	(0,1)
(2,0)	(2,0)	(3,0)	(0,0)	(1,0)	(0,2)	(1,2)	(0,1)	(1,1)
(3,0)	(3,0)	(0,0)	(1,0)	(2,0)	(1,2)	(0,1)	(1,1)	(0,2)
(0,1)	(0,1)	(1,2)	(0,2)	(1,1)	(0,0)	(3,0)	(2,0)	(1,0)
(1,1)	(1,1)	(0,1)	(1,2)	(0,2)	(1,0)	(0,0)	(3,0)	(2,0)
(0,2)	(0,2)	(1,1)	(0,1)	(1,2)	(2,0)	(1,0)	(0,0)	(3,0)
(1,2)	(1,2)	(0,2)	(1,1)	(0,1)	(3,0)	(2,0)	(1,0)	(0,0)

Table 1: Cayley multiplication table of the group of order 8 constructed with the `CAM_DETROT90` and `CAM_FLIPXY` keywords. The operation on the left is executed before the operation on the top.

The 8 group elements are

- the unit element (no change of the image),
- the three pure rotations $(r, 0)$ with $r = 1, 2, 3$—generated by $(1, 0)$ of order 4—,
- the two pure flips $(0, 1)$ and $(0, 2)$—each of order 2—,
- and the two flips along the two diagonals, $(1, 1)$ and $(1, 2)$—each of order 2.

The group is isomorph to D_8, the dihedral group with 8 elements.

A.3 Remote Sound

This is a user's note that has nothing to do with GEIRS; any other means of the local computer network may be implemented as well. It is only of interest if operators need to hear GEIRS sound effects.

The computer that runs GEIRS may or may not have a sound card—see the output of any of the commands

```
cat /proc/asound/cards
amidi -l
/usr/sbin/alsa-info.sh
```

Usually GEIRS will be run on a remote server in the catacombs of the observatory, whereas the sound is supposed to be trumpeted on some controller's desktop. In that case the GEIRS computer does not need a sound card.

There is at least one technique to forward the sound to the operator under openSUSE, which feeds the digitized pulse modulation into a PulseAudio channel on the GEIRS (=remote) computer, and forwards this as an RTP package to the `pulseaudio` channel on the operator's (=local) machine, Figure 38. This is configured basically as follows:

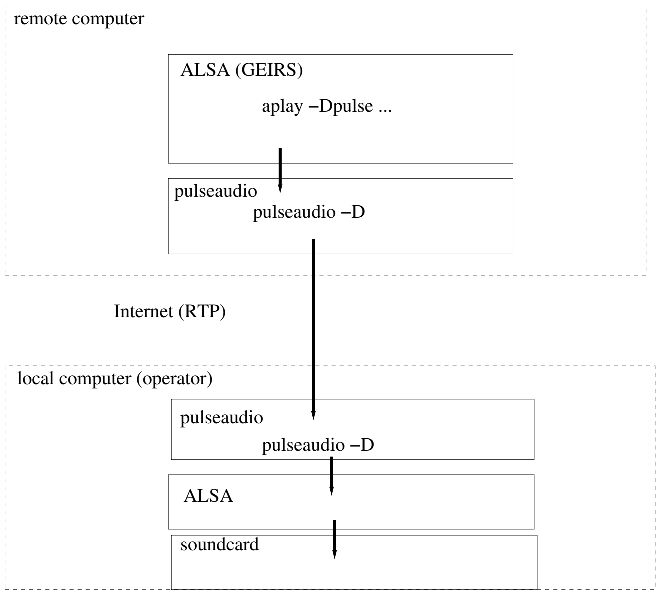


Figure 38: Potential of sound forwarding

1. Install the `paprefs` (pulseaudio preferences) openSUSE module on the remote and also on the local computer.

   If

   ```
   which paprefs
   ```

   does not show anything, this is essentially done by calling `sudo /sbin/yast2`, selecting the `Software management` submenue, searching for `paprefs` and downloading and installing it.

   There are two variants to configure the forwarding.

- `paprefs` is then called on the local computer, setting the `Network Access` to *Make... PulseAudio network... available locally*, setting the `Network Server` to *Enable network access to local sound devices*, setting the `Multicast/RTP` to *Enable Multicast/RTP receiver.* Again `paprefs` is called on the remote workstation, but setting `Multicast/RTP` to *Enable Multicast/RTP sender* and *Create separate audio device for....*

  `paprefs` can alternatively be called from the Desktop menue via `System` → `Configuration` → `PulseAudio Preferences`.

  The disadvantage of this setup is that the remote computer broadcasts continously the local audio stream to every other computer on the network, which eats bandwidth and is a waste of resources.

- An equivalent setup can be reached by enabling the TCP related modules in `/etc/pulse/default.pa` on the two machines by removing the hash marks before the two `tcp` lines and the `zeroconf` line. `paprefs` is then called on the local computer, setting the `Network Access` to *Make... PulseAudio network... available locally*, setting the `Network Server` to *Enable network access to local sound devices* and *Don't require authentication*, and not checking any of the *Multicast/RTP* buttons. Again `paprefs` is called on the remote workstation, but not enabling any of the options in the submenues.

  `paprefs` can alternatively be called from the Desktop menue via `System` → `Configuration` → `PulseAudio Preferences`.

These calls modify the `$HOME/.gconf/system/pulseaudio` files on the two computers and "called" from there with the aid of the `module-gconf` in `/etc/sound/default.pa`.

2. Enable pulseaudio either with

```
setup-pulseaudio --enable
```

or with `sbin/yast2` under `System` → `/etc/sysconfig Editor` → `Hardware` → `Soundcard` → `PulseAudio` such that the `PULSEAUDIO_ENABLE="yes"` appears in `/etc/sysconfig/sound`.

3. On the remote computer the `pulseaudio` server needs to run. This can be checked with

```
ps -C pulseaudio
```

and is generally implemented by a non-comment line of the format

```
autospawn = yes
```

in `/etc/pulse/client.conf`. If this does not work, start the `pulseaudio` server on the remote computer manually:

```
pulseaudio --start
```

and if this is refused with

```
pulseaudio -D
```

(This might be included in the `scripts/GENERIC` of the GEIRS startup because the call is harmless if the server is already running.) On the local computer it probably is running already, because this would have detected the sound card:

```
pactl info
```

If one of the `pulseaudio` is not running, `aplay` or `paplay` will show (misleading) error messages of the form "connection refused."

4. An intermediate test of the functionality is that pulseaudio works on the local machine, to be tested by copying a sound file to that machine and playing it with

   ```
   paplay *.au
   ```

5. Tell the server on the local workstation to accept the stream from the remote workstation. The least fuzzy way is to forward that information by accessing the remote computer with the `-X` switch of the `ssh`, such that the cookie appears on the remote computer, which can be checked with

   ```
   xprop -root | fgrep PULSE
   ```

   on the remote computer. If this information does not show up on the remote machine, either

   ```
   start-pulseaudio-X11
   ```

   or (more painfully) uncommenting the `load-module module-x11-publish` in `/etc/pulse/default.pa` on the local machine—before calling the `ssh`—may be needed.

   The files `$HOME/.pulse-cookie` in the home directories of the two computers seem to be no longer in use.

6. If alsa is used on the remote workstation, tell it to feed the output into its `pulseaudio`. The appropriate configuration is probably already in `/etc/asound-pulse.conf` on the remote workstation.

   ```
   # PulseAudio plugin configuration

   pcm.!default {
       type pulse
       hint {
           show on
           description "Default ALSA Output (currently PulseAudio Sound Server)"
       }
       fallback "sysdefault"
   }

   ctl.!default {
       type pulse
       fallback "sysdefault"
   }
   ```

   Since the (reverse) feeding of the pulseaudio channel to the alsa channel is likely also needed on the local workstation, an equivalent file is likely also needed on the local file system.

7. On the remote workstation, tell the `pulseaudio` server which machine ought to receive its output by setting the `PULSE_SERVER` variable to the local host:

```
RMHOST=‘who -m | awk ’{print $5}’ | sed ’s/[()]//g’‘
# RMHOST=‘echo $SSH_CLIENT | awk ’{print $1}’‘  # alternative
export PULSE_SERVER=$RMHOST
```

This might be inserted (after translation to `csh` syntax) in the `$CAMHOME/scripts/GENERIC` file on the remote workstation. If this forwarding service is also needed for other programs, it is a good idea to add these few lines also to the user's `.bash_login`. Whether the numerical IP-address is needed depends on the avialability of a DNS server from the remote computer.

8. Set the environment variable `CAMAUDIOPLAY` (in the `scripts/GENERIC`) on the remote machine to `paplay`, such that `aplay` on the GEIRS workstation feeds its output of the audio file to its local `pulseaudio` daemon.

The installation is working once the command

```
cd $CAMHOME/SOUNDS
aplay -Dpulse rooster.au
paplay rooster.au
```

on the remote (GEIRS) workstation plays sound on the local workstation. If the call

```
cd $CAMHOME/SOUNDS
paplay rooster.au
```

on the remote workstation still says "connection refused," this may be caused by a firewall on the local workstation—as for example enabled by default on fresh openSUSE 13.1 installations. The firewall must then be weakend (or just shut down) via `/sbin/yast2`, allowing the TCP packages from the remote computer with port 4713: `system`→`Security and Users`→`Firewall`.

A.4 Network Time

Under openSUSE, configuration of the NTP is to be done in `/etc/ntp.conf`, or easier with the network configuration within `yast`. The daemon appears as `/usr/sbin/ntpd` with `ps -ef | fgrep ntp`. A running daemon does not guarantee that the clock on the system is updated, for example if hosted behind a firewall[32], so it is advised to monitor `/var/log/ntp` or the equivalent `logfile` set in `/etc/ntp/conf` for the (irregular) corrections and to check that for example `ntpdate pool.ntp.org` or whatever server is mentioned in `/etc/ntp.conf` is responding.

Under CentOS 7, we edit `/etc/chrony.conf` (for example adding

```
server time.mpia-hd.mpg.de iburst
```

at the MPIA), then

```
systemctl enable chronyd.service
systemctl start chronyd.service
```

[32]this is the MPIA case. `nslookup time` will reveal the IP address of the local time server

A.5 X11

A.5.1 Forwarding

Under newer versions of openSUSE X11 forwarding with `ssh -X` may fail because the `DISPLAY` variable is not forwarded, although the forwarding is enabled in `/etc/ssh/sshd_config`. The solution of the problem is to enable `IPv6` in the network configuration of the remote workstation, or to set the `AddressFamily` explicitly to `inet` (thus replacing the default, which is `any`).

Remote login from another place to a workstation may fail if the ssh daemon is not enabled on the remote site. To enable it, use `/sbin/yast2`, the submenue `Security and Hardening`, then the submenue `Enable extra services in runlevel 5` and switch the entry for the `sshd` to `Yes`.

If the GEIRS workstation is hidden in a remote local network, the usual mechanism with port matching and X11 forwarding may be used. The example is

```
irws2> ssh -X yoursshname@ssh.lbto.org
```

and then in that new shell on the intermediate machine

```
ssh> ssh -X geirsusername@Luci.luci.lbto.org
```

to log into a remote machine on the LBT network. We showed the prompts to illustrate on which computer's shell these commands are entered. Note that incomplete names like `luci.luci` do no longer work since changes in the DNS in the network in 2014.

If one needs to work on the remote machine with `sudo(8)` mechanisms, permissions to use the X11 interface need also to be added before trying to open GEIRS or other windows `xauth(1)`.

```
xauth list
sudo -u effnewuser /bin/bash -i
# touch ~/.Xauthority # usually only needed for new users here
echo $DISPLAY
# Below add the full line after the 'add' that was the output of the
# previous xauth command. The correct line is the one which (almost)
# matches the current setting of DISPLAY. If DISPLAY is for example
# 'localhost:13', take the line from the 'list' that has 'somehost/unix:13'.
xauth add ... MIT-MAGIC-COOKIE-1 ...
```

A.5.2 Tunneling

Supposed one whishes to exchange files with a remote computer on the LBT network, this can basically be done by copying them first to `ssh.lbto.org` and from there to the destination. There are two possible directions of such a transfer. The example to copy a file `tst.txt` is

1. From the local computer named `irws2` to the remote computer named `luci.luci.lbto.org`:

   ```
   irws2> scp -p tst.txt yoursshname@ssh.lbto.org:.   # copy from local computer to ssh
   irws2> ssh -X yoursshname@ssh.lbto.org           # log into the ssh
   ssh> scp -p tst.txt geirsname@luci.luci.lbto.org:.  # transfer file to luci
   ssh> rm tst.txt   # clean up file on ssh
   ssh> ~.     # log out from ssh
   ```

2. From the remote computer to the local computer:

```
irws2> ssh -X yoursshname@ssh.lbto.org           # log into the ssh
ssh> scp -p geirsname@luci.luci.lbto.org:tst.txt .   # copy from remote computer to ssh
ssh> ~.     # log out from ssh
irws2> scp -p yoursshname@ssh.lbto.org:. .  # transfer file from ssh to local
irws2> ssh -X yoursshname@ssh.lbto.org           # log agin into the ssh
ssh> rm tst.txt    # clean up ssh intermediate copy
```

This chain of copying is complicated, and needs local disk space on the `ssh` intermediate computer that ought to be cleaned up. The more elegant alternative is to set up a tunnel that passes the data from the local computer to the remote computer, such that no intermediate files are created. There are again two directions. The most common task is to copy the FITS files from a remote disk to your local disk as follows. First set up a tunnel through the intermediate computer calling

```
irws2> ssh -X -N -L 2022:xxx.yyy.www.zzz:22 yoursshname@ssh.lbto.org
```

on your local computer. (This command will respond nothing, so the output seems to hang after the password was typed in.) The `xxx.yyy.www.zzz` should be the IP address of the remote computer, for example `192.168.60.12` for `luci.luci`. Then transfer the files with

```
irws2> scp -p -r -P 2022 geirsname@localhost:/dir/full/path/on/luci  /full/path/on/irws2
```

using the same number after the `-P` as the first port number in the previous tunneling setup. It is useful to move first into the target directory on the local computer, so the dot (.) can be used as the destination address. To use wild cards in the remote file names, surround the URI with simple quotation marks:

```
irws2> cd /full/path/on/irws2
irws2> scp -p -r -P 2022 'geirsname@localhost:/dir/full/path/on/luci/*.fits'  .
```

A.5.3 NX client

To connect via tunneling through the LBTO port machine to a remote computer on the LBT network with newer versions of NX, first set up a tunnel through `ssh.lbto.org`

```
irws2> ssh -X -N -L 2022:xxx.yyy.www.zzz:22 yoursshname@ssh.lbto.org
```

in one terminal. (This will not show anything after you typed in your password and seems to hang.) Here `xxx.yyy.www.zzz` is the IP address of the remote computer; using a symbolic name like `luci.luci` may no longer work. Then start the NX client with

```
nxplayer  (under Linux)
nxplayer.exe  (under Windows)
```

in another window. If the command `nxplayer` is not found under Linux, use the full path name of the installation to start (`/usr/NX/bin/nxplayer`) or add `/usr/NX/bin` to the `PATH`. If `/usr/NX` is absent, install the software by downloading the RPM package from the company and install it first (as root) with

```
yum install nomachine_4.6.4_13*.rpm (under CentOS)
zypper install nomachine_4.6.4_13*.rpm (under openSUSE)
```

In the NX configuration use

- `ssh` as the protocol,
- use the same port as with the tunnel (2022 in the example),
- use the `localhost` as the machine to connect to,
- use the login account (for example `readout1` and password on the remote machine)

Just after installation, the NX support is running under an openSUSE system (`ps -elf | fgrep nx`), because `/etc/systemd/system/multi-user.target.wants` contains a `nxserver.service` entry. To disable this automated start each time the computer boots, use `/sbin/yast2`, the `System` submenue with the `Service Manager`, and disable the `nxserver`. In this case one needs to activate the service explicitly (as root) either from the same menue or by calling `/etc/NX/nxserver --startup`.

A.5.4 x2go

If the operating system is openSUSE 13.2, `x2go` is installed on the remote workstation with

```
zypper ar obs://X11:RemoteDesktop:x2go/openSUSE_13.2 x2go
zypper in x2goclient
```

If the operating system is CentOS 7, `x2go` is installed on the remote workstation with

```
yum install epel-release
yum --enablerepo=epel install x2goserver-xsession
yum --enablerepo=epel install x2goclient
```

The session is started with

```
x2goclient
```

Note that GNOME sessions seem not to work, only KDE sessions.

A.5.5 Fonts

If the font system of the current X11 system does not offer the `courier-medium` and `courier-bold-r` fonts for the GUI's (revealed with `xfontsel` and `xlsfonts`) a modest adaptation is available by changing the

```
setenv CAMFONT courier
```

in `GEIRS/scripts/GENERIC` to another standard font, for example `fixed`.

A.6 FITS

A.6.1 Chopping MEF

If images have been stored in the extensions and we wish to create versions with images in the primary header, the `ftcopy` command of the heatools is one way to create copies of that simpler format.[33] Example: the four images extensions `win1_1`–`win2_2` of the FITS file `dcrsave0007.fits` are restored in four new FITS files `tmp_win`*i*`.fits` with the four Linux commands

```
heainit # not necessary if already in ~/.bash_login
ftcopy 'dcrsave0007.fits[win1_1]' tmp_win1.fits copyall=no
ftcopy 'dcrsave0007.fits[win1_2]' tmp_win2.fits copyall=no
ftcopy 'dcrsave0007.fits[win2_1]' tmp_win3.fits copyall=no
ftcopy 'dcrsave0007.fits[win2_2]' tmp_win4.fits copyall=no
```

The usual way to open both detector images at the same time with `ds9` is

`ds9 -multiframe -cmap bb` *file.fits*

Since March 2015 a 2D WCS coordinate system in units of milli-meters has been added to the FITS headers, so one can also use for example

`ds9 -mosaicimage -cmap bb -zoom 0.5` *file.fits*

to render the image with an approximately correct gap between the two chips.

A.6.2 ds9loop

A command `ds9loop` with the syntax

`ds9loop` *[ds9options. . .] dir1 [dir2 . . .]*

is in the GEIRS scripts which calls `ds9` in a loop over all fits files in the named directories. The only required interaction by the user is to close `ds9` for moving on to the next. Examples:

```
ds9loop .
ds9loop -mosaicimage /data1/Panic
```

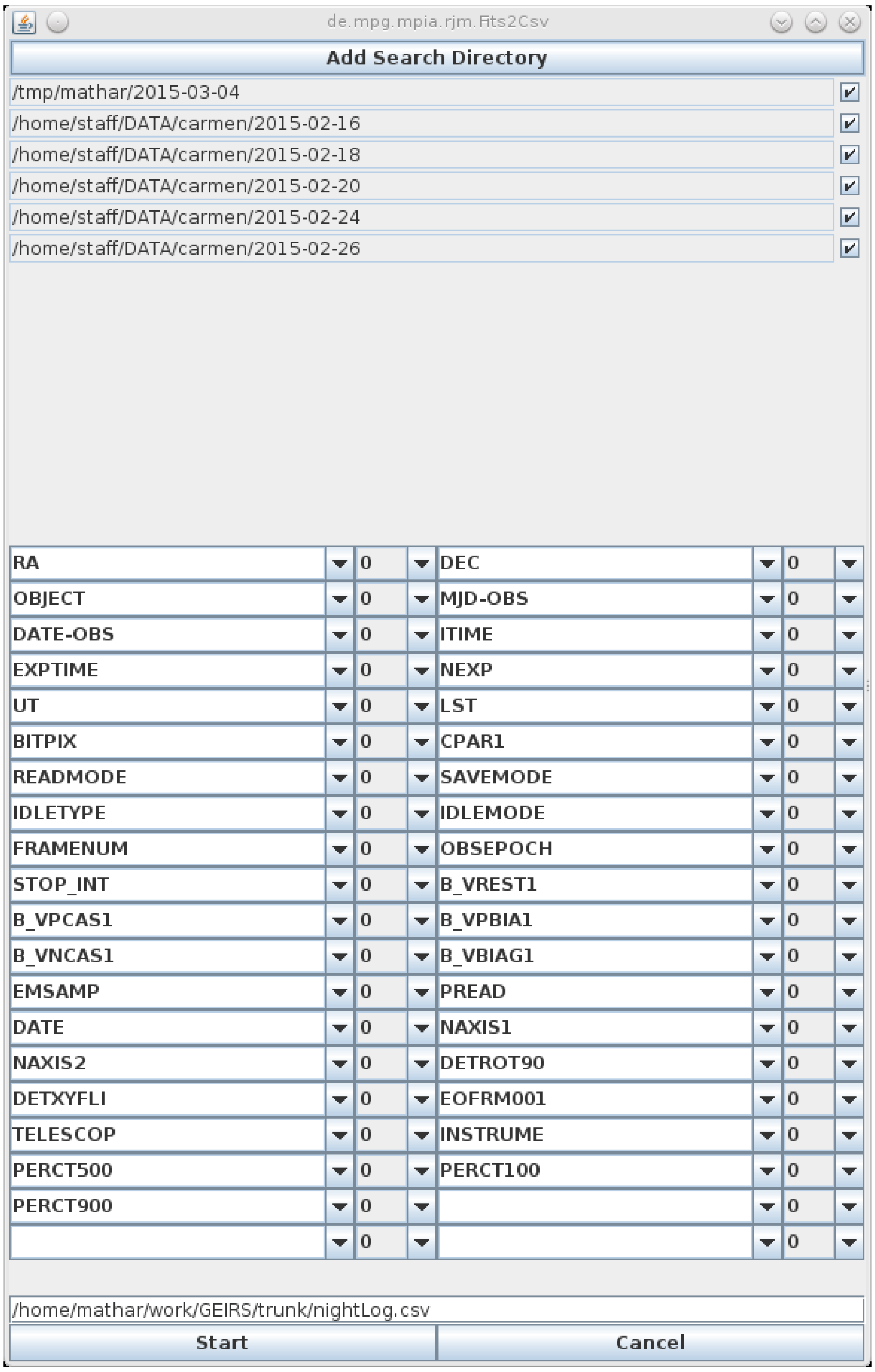
A.6.3 fits2csv

The program `fits2csv` opens the GUI of Figure 39 and scans recursively a list of directories for all files with suffix `.fits`. The FITS header keywords that match a finite list of strings defined by the user are searched in a HDU of each of the files and written as a comma-separated list of values (CSV), into a text file specified by the user.

The keywords should be provided as regular expressions of the form `HIER.*`*keyword* if there are some general hierarchical prefixes in front of them.

The standard way of using this new text file is to open it with a spread-sheet editor like open office, specifiying the comma as the delimiter.

[33] This is a user's note that has nothing to do with GEIRS.



de.mpg.mpia.rjm.Fits2Csv

Add Search Directory

/tmp/mathar/2015-03-04 ✓
/home/staff/DATA/carmen/2015-02-16 ✓
/home/staff/DATA/carmen/2015-02-18 ✓
/home/staff/DATA/carmen/2015-02-20 ✓
/home/staff/DATA/carmen/2015-02-24 ✓
/home/staff/DATA/carmen/2015-02-26 ✓

RA	0	DEC	0
OBJECT	0	MJD-OBS	0
DATE-OBS	0	ITIME	0
EXPTIME	0	NEXP	0
UT	0	LST	0
BITPIX	0	CPAR1	0
READMODE	0	SAVEMODE	0
IDLETYPE	0	IDLEMODE	0
FRAMENUM	0	OBSEPOCH	0
STOP_INT	0	B_VREST1	0
B_VPCAS1	0	B_VPBIA1	0
B_VNCAS1	0	B_VBIAG1	0
EMSAMP	0	PREAD	0
DATE	0	NAXIS1	0
NAXIS2	0	DETROT90	0
DETXYFLI	0	EOFRM001	0
TELESCOP	0	INSTRUME	0
PERCT500	0	PERCT100	0
PERCT900	0		0
	0		0

/home/mathar/work/GEIRS/trunk/nightLog.csv

Figure 39: The GUI called in by `fits2csv`

A.6.4 FTOOLS

The heatools mentioned at many places in this manual are compiled as follows:

1. Ensure that you have a recent version of compilers of your operating system, including `gfortran`. On openSUSE for example, use `/sbin/yast2`, the software management, and look into the RPM group under `Development - Languages - Fortran`. You may also need to install the `libxt-devl` package such that `X11/Intrinsics.h` is known.
2. Download the source code from the download page. Select the `Source code` (CentOS or openSUSE), not any precompiled binaries, and select the `General-Use FTOOLS`, and click `Submit`. Download everything (roughly 80 MB) to `$HOME/heasoft-6.16src.tar.gz`.
3. Unbundle with

   ```
   cd $HOME
   rm -rf heasoft-6.16
   tar xzf heasoft-6.16src.tar.gz
   ```

4.
   ```
   cd heasoft-6.16
   cd BUILD_DIR
   ./configure --x-libraries=/usr/lib --x-includes=/usr/include # openSUSE 13.2
   ./configure # CentOS 7
   nice make > build.log 2>&1
   nice make install > install.log 2>&1
   chmod +x headas-init.*
   ```

5. add to `$HOME/.bash_login` (details of the libc will probably differ):

   ```
   export HEADAS=${HOME}/heasoft-6.16/x86_64-unknown-linux-gnu-libc2.19
   . $HEADAS/headas-init.sh
   ```

   and make sure that your terminals are login terminals.